Wireless World

May 1973 20p

Meterless transistor tester

Colour telephoto system

Australia 70 cents	Germany Dm. 3.50	New Zealand 65 cents	Spain Ptas. 55.00
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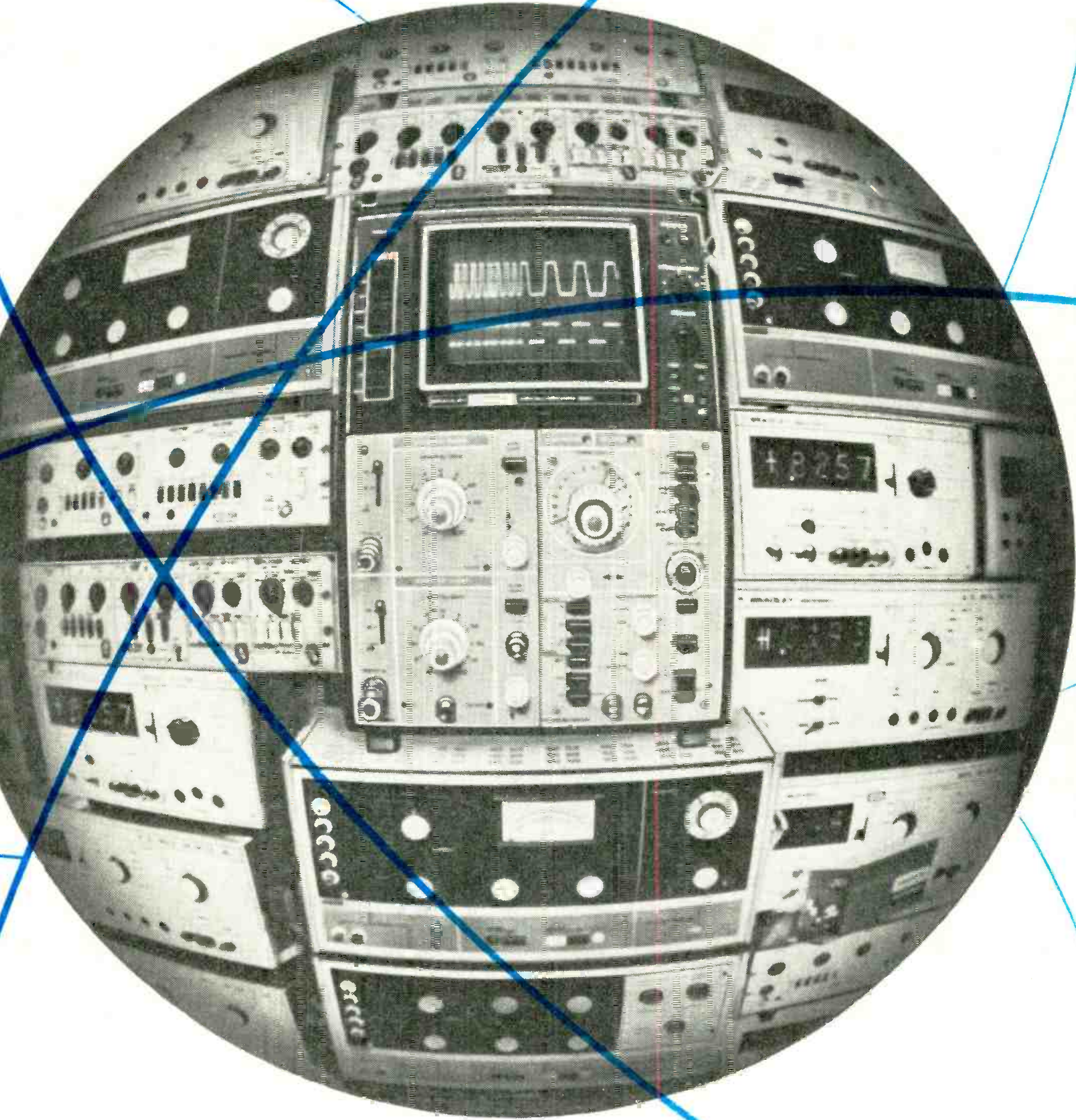
Finland Fmk. 4.30	Malaysia M$ 2.30	South Africa 65 cents	

In an ever changing world...



There is one constant that you can rely on – the continuing quality of Bradley instruments. The comprehensive range includes everything you need to measure, test and calibrate, from a new generation 100MHz oscilloscope to a complete, yet compact multimeter calibration station.

They're all realistically priced and backed by Bradley's nationwide service network. Most are available with our own B.C.S. certificate.

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BRADLEY electronics

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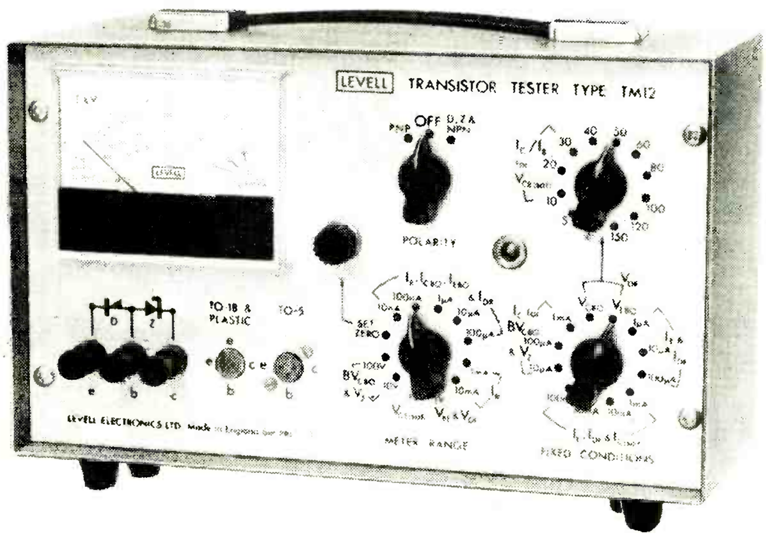
WW—004 FOR FURTHER DETAILS

LOW COST TRANSISTOR TESTERS

LEVELL
PORTABLE INSTRUMENTS

VISIT US ON STAND 621 AT L. E. C. S. 73
OLYMPIA, LONDON, 22-25 MAY



VOLTAGE UP TO 150V.
LEAKAGE DOWN TO 0·5nA.

Tests bipolar transistors, diodes and zener diodes. Measures leakage down to 0.5 nA at 2V to 150V. Current gains are checked from 1μA to 100mA. Breakdown voltages up to 100V are measured at 10μA, 100μA and 1mA. Collector to emitter saturation voltage is measured at 1mA, 10mA, 30mA and 100mA for I_C/I_B ratios of 10, 20 and 30. The instrument is powered by a 9V battery and a transistor D.C. to D.C. converter to produce 150V.

TRANSISTOR RANGES (PNP OR NPN)

I_{CBO} & I_{EBO}:	10nA, 100nA, 1μA, 10μA and 100μA f.s.d. acc. ±2% f.s.d. ±1% at voltages of 2V, 5V, 10V, 20V, 30V, 40V, 50V, 60V, 80V, 100V, 120V, and 150V acc. ±3% ±100mV up to 10μA with fall at 100μA <5%+250mV. Short circuit current limit 1mA.
BV_{CBO}:	10V or 100V f.s.d. acc ± 2% f.s.d. ±1% at currents of 10μA, 100μA and 1mA ± 20%. Open circuit voltage limit 150V.
I_B:	10nA, 100nA, 1μA ... 10mA f.s.d. acc. ±2% f.s.d. ±1% at fixed I_E of 1μA, 10μA, 100μA, 1mA, 10mA, 30mA, and100mA acc. ±1%. V_{CE}=2V approx.
h_{FE}:	3 inverse scales of 2000 to 100, 400 to 30 and 100 to 10 convert I_B into h_{FE} readings. Acc. is ±(2+200 ÷ % of f.s.d.)% i.e. ±4% at f.s.d.
V_{BE}:	1V f.s.d. acc. ±20mV measured at conditions on h_{FE} test.
$V_{CE(sat)}$:	1V f.s.d. acc. ±20mV at collector currents of 1mA, 10mA, 30mA and 100mA with I_C/I_B selected at 10, 20 or 30 acc. ±20%.

DIODE & ZENER DIODE RANGES

I_{DR}:	As I_{EBO} transistor ranges.
V_Z:	Breakdown ranges as BV_{CBO} for transistors.
V_{DF}:	1V f.s.d. acc. ±20mV at I_{DF} of 1μA, 10μA, 100μA, 1mA, 10mA, 30mA and 100mA acc. ±1%.

POWER SUPPLY
One type PP9 battery, or A.C. mains when a LEVELL Power Unit is fitted.

SIZE & WEIGHT
7″ x 10¼″ x 5½″. 8 lbs

NOTE: All prices subject to V.A.T.

type TM12 £65

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WW—006 FOR FURTHER DETAILS

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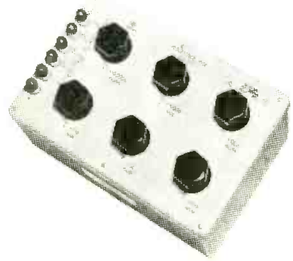
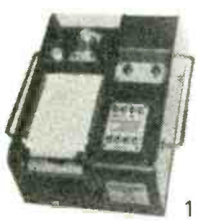
Bench mounted fully shrouded.
Input: 120, 220 and 250V.
Output: 0–260V.
Max. load 2 Amps.
£6.55

SIX-DECADE 0.01 CLASS RESISTANCE BOX TYPE P327*



6 decades of 0.1-1-10-100-1000-10,000 Ω steps. Decades and their respective wipers are brought out to separate terminals.
All-metal construction, fully screened.
Capacity: 0.3A for 0.1 and 1 Ω decades; 0.1A for 10 Ω decade, 0.03A for 100 Ω decade; 0.01A for 1000 Ω decade and 0.003A for 10,000 Ω decade.
£65.00

PEN RECORDERS



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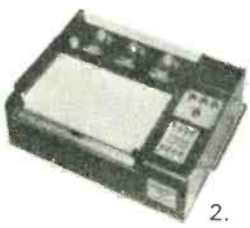

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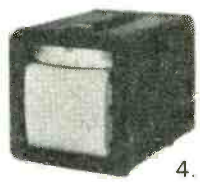

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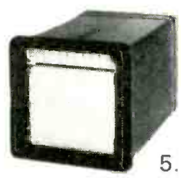

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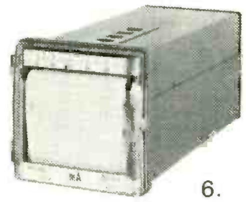

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1. H320-1 High speed single channel
2. H320-3 High speed three channel
3. H390 Multi-range AC/DC Recorder
4. H352 Portable single channel 1mA.
5. H30 10-channel event recorder
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2. ~~Double beam C1-16 5MHz~~
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5. Wide band C1-54 (20 MHz) oscilloscope
6. Solid State C1-49 5MHz oscilloscope

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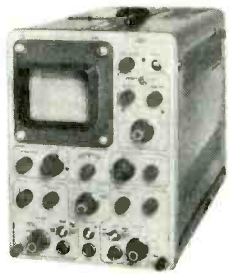

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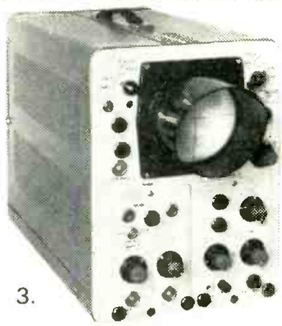

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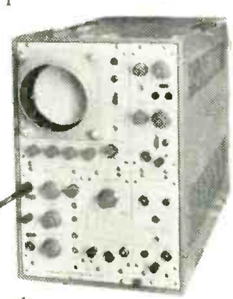

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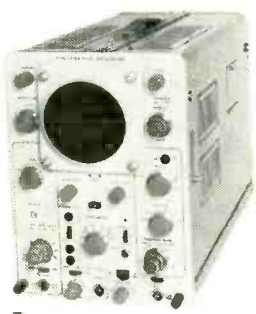

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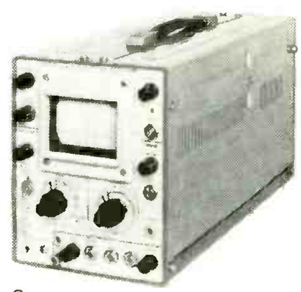

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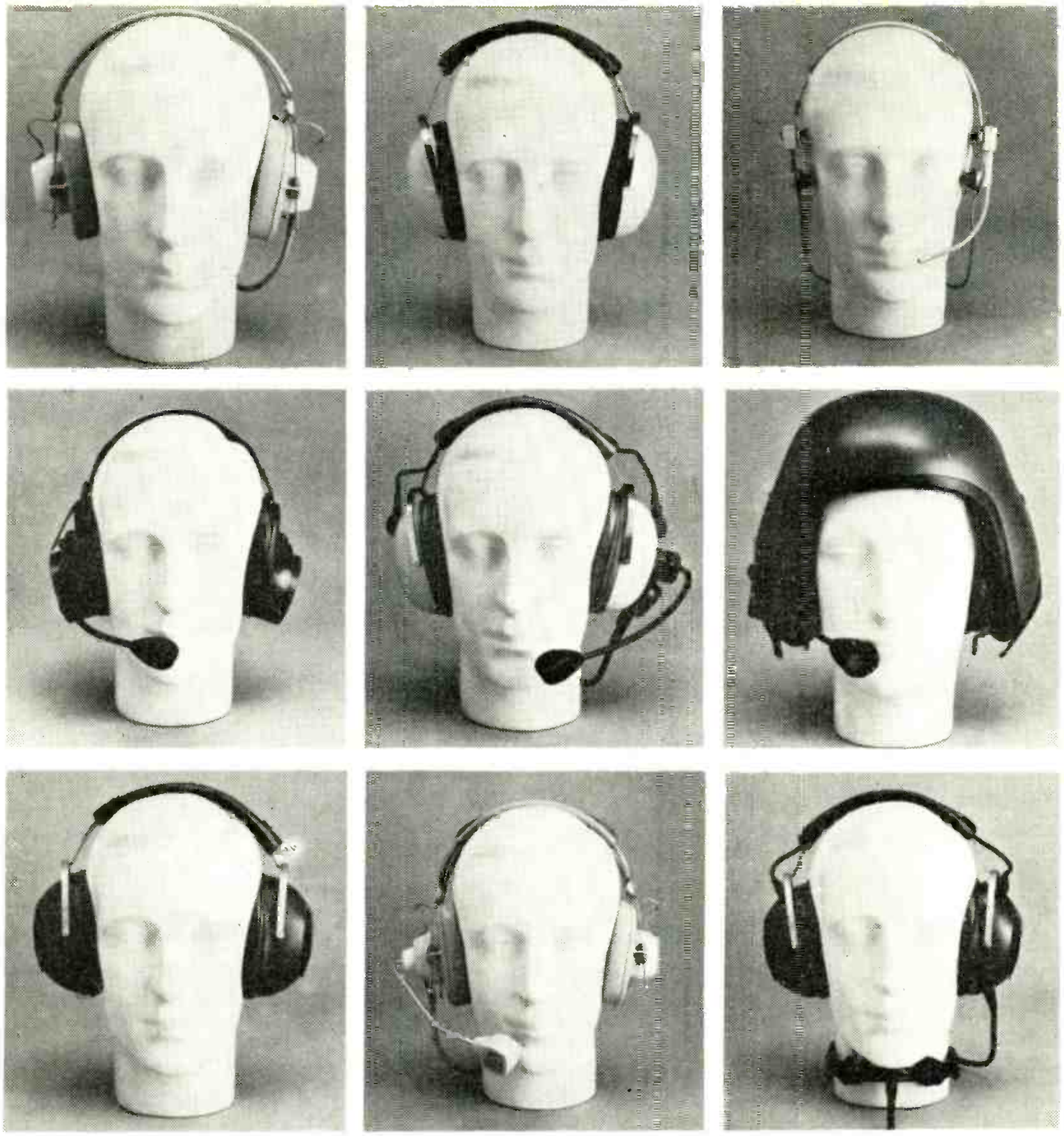

Nine sound reasons for choosing Amplivox headsets

We'd like to give you some sound advice. For headsets of any kind, look to the specialists...Amplivox. World technological leaders in communications headsets, Amplivox offer equipment that meets any environmental situation.

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Through to Minilite, a new lightweight that introduces a comfort revolution into conventional headset design. Amplivox design leadership not only makes Minilite super-efficient but super-economic, too.

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The Electronics Group

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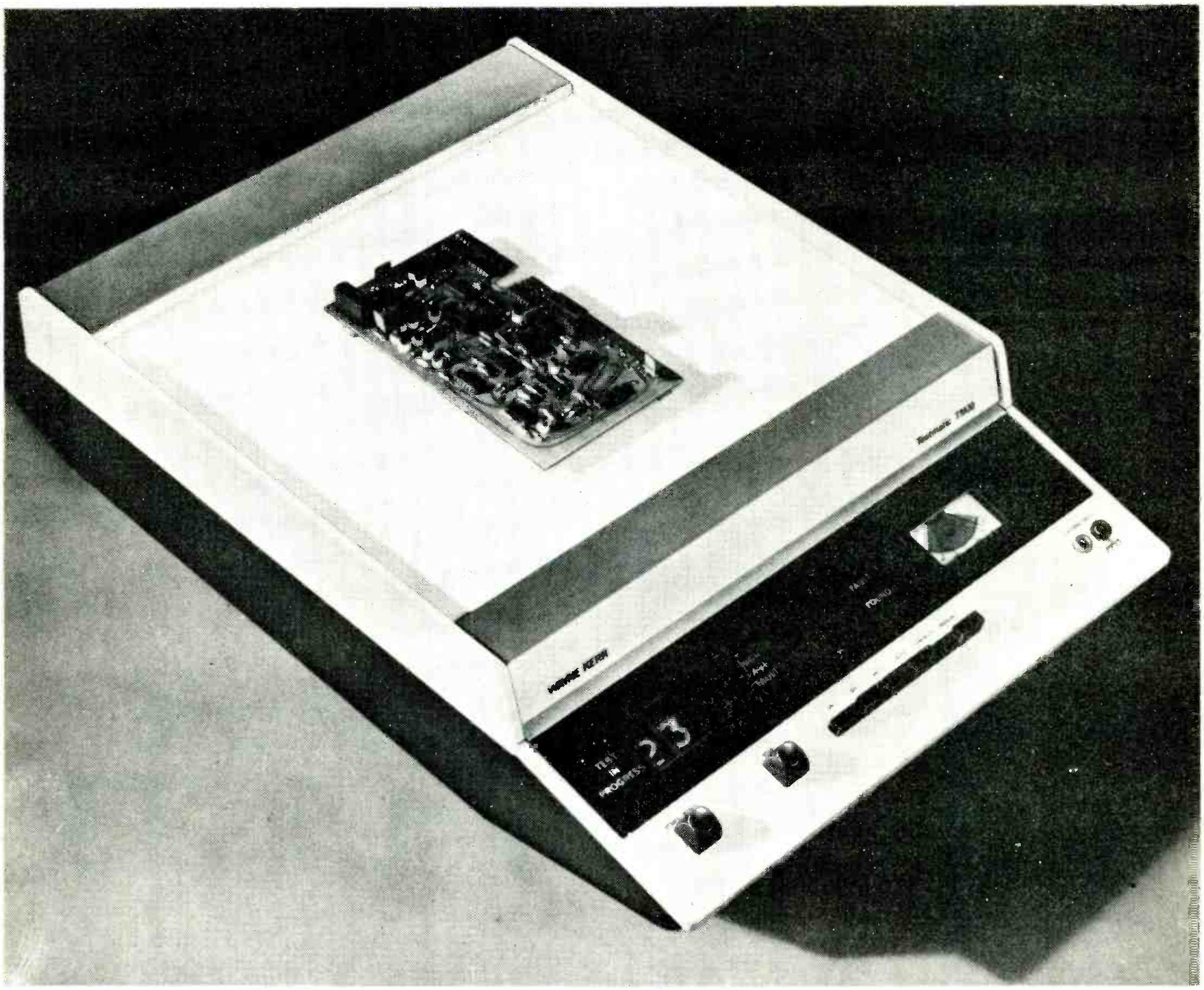
Middlesex. HA0 1RU. England.
Telephone: 01-902 8991

Name__________
Company__________

Address__________

My headset requirement is______

WW/5/73



The simple truth about the Wayne Kerr TM30

The Testmatic TM 30 has been developed for efficient circuit-board testing, in the light of operational experience with the TM 60. It is designed to be worked by people who – whatever other talents they may have – need not be qualified electronics engineers. In saving time it thereby saves you money.

It will tell the operator where there is a fault, as well as indicating by how much the value is high or low. And it can handle 30 tests – in seconds.

WAYNE KERR

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For more information phone Bognor Regis (02433) 4501, or fill in the coupon.

Please send details of the TM 30.

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Company name______________________

and address______________________

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WW—010 FOR FURTHER DETAILS

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As a result of our new production line, your loading bay is reached much cheaper and quicker.

We believe that our quality remains unchallenged.

Delivery – we offer the most reliable delivery in the Business.

We'd like to hear from you. If the quantities you use are large enough, maybe we can upset your marketing plans even more!

Please write to Ronald Gorton and ask him to tell you how.

MARRIOTT MAGNETICS LTD

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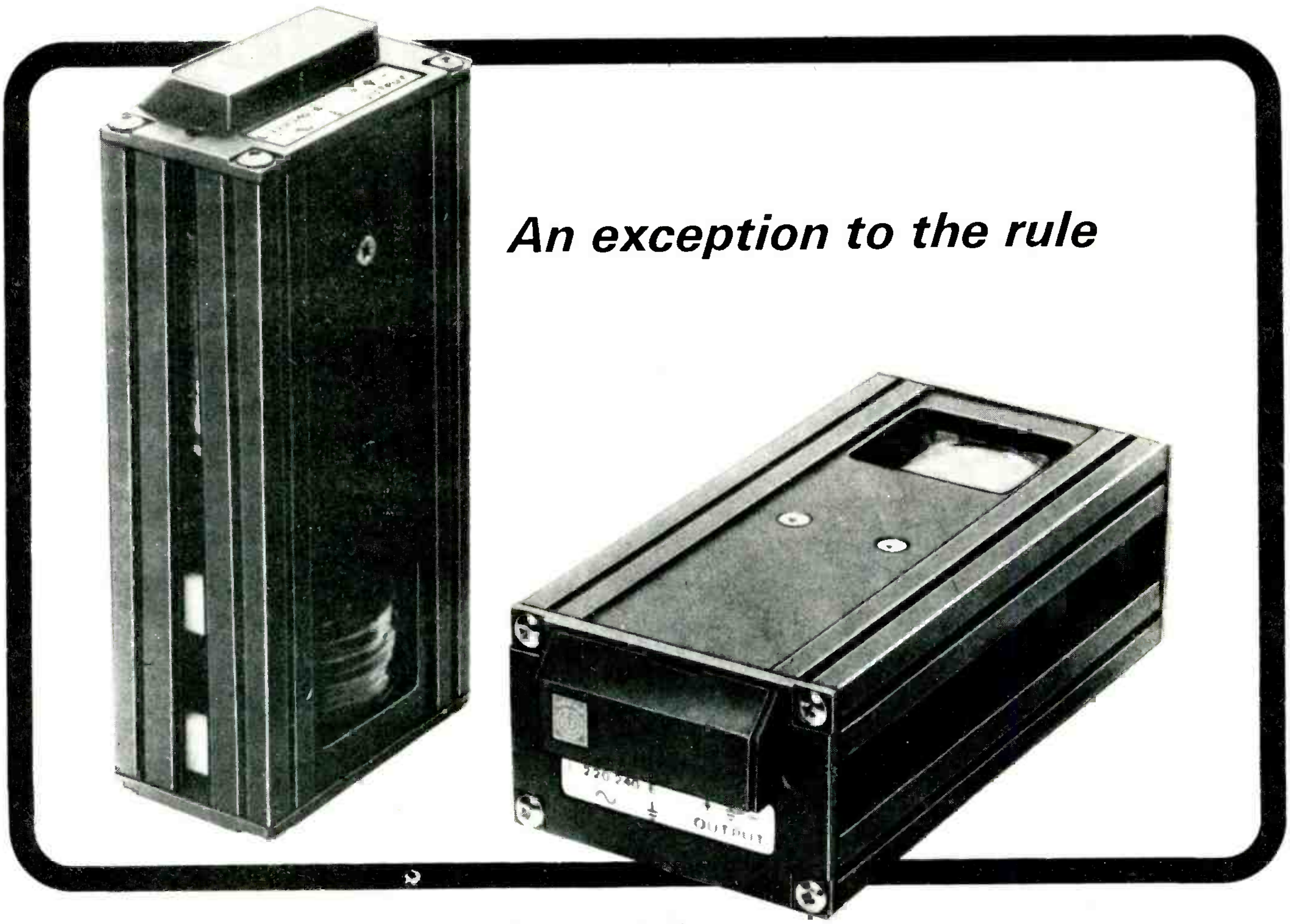

An exception to the rule

Cheap power supplies can be expensive — but there's always an exception to the rule. Here's ours.

These new miniature d.c. power supplies are well engineered and compact. They're suitable for either bench use or for incorporating into original equipment and they feature good regulation, low ripple and full protection.

Send for the leaflet (better still, try a unit) and we think you'll agree—they *are* excellent units and surprisingly inexpensive.

Instant miniature power from:—

Units available

GROUP 1 UNITS: Dimensions (mm) 35H x 64W x 128D. Wt. 0.51kg

Model	OUTPUT: Adjust range (Vd.c.) min. max.	Current rating (mA) at T. amb. 30°C	40°C	60°C	PRICE* 0-9 units
6/500P	4 — 6	500	500	250	£13
12/250P	6 —12	250	250	125	£12
24/125P	12 — 24	125	125	62.5	£12
15/15/100P	12–17 O 12–17	100	100	50	£13.50
GROUP 2 UNITS: Dimensions (mm) 40H x 64W x 131.5D Wt. 0.51kg.					
6/1P	4 — 6	1000	750	250	£15
12/500P	6 — 12	500	500	250	£14
24/250P	12 — 24	250	250	125	£14
15/15/200P	12–17 O 12–17	200	200	100	£16

*(Excludes VAT)

Farnell

POWER SUPPLIES DIVISION

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WW—013 FOR FURTHER DETAILS

If you're spending £44 on a transcription turntable, you deserve to know who made it.

It's easy to spend a lot more than £44 on a turntable that isn't really made by the people who put their name to it.

At BSR, we believe in taking the trouble to make all the vital components ourselves.

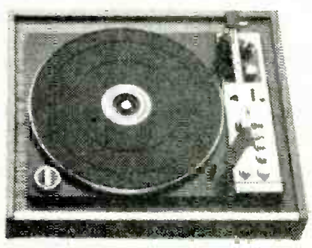
And it pays.

Gradually, we've built a name for reliability that is second to none. The 810 and 710 here, are the finest turntables we've ever made.

We designed them to give you a freedom unequalled by most other turntables.

Freedom from audible rumble. Freedom from wow and flutter.

Freedom from normal tracking error.



We'll explain all the finer details when we send you our free illustrated brochure. Or better still, when you join us on Stand 747 at the London Electronic Component Show, Olympia, 22-25 May.

BSR
McDONALD

We put more into our turntables.

To: BSR Limited, McDonald Division, Monarch Works, Cradley Heath, Warley, Worcs.
Please send me the new BSR McDonald brochure by return of post.

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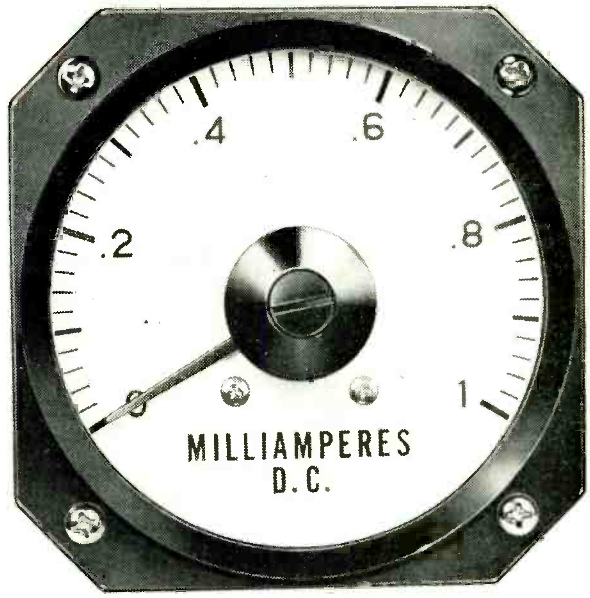
WW 1A

ANDERS MEANS METERS...

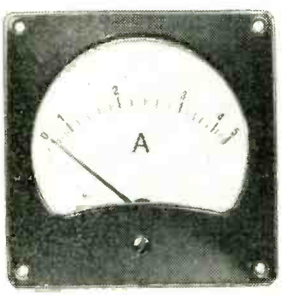
LANCASTER RANGE 240°

- Models CS60 and CS80 with scale lengths of 4″ and 5.5″.
- S.A.E. styling in matt black moulded case.
- Employed extensively for Tachometry, Simulator and Marine applications.
- Availability from sensitivities of 200 microamps
- Competitive prices.

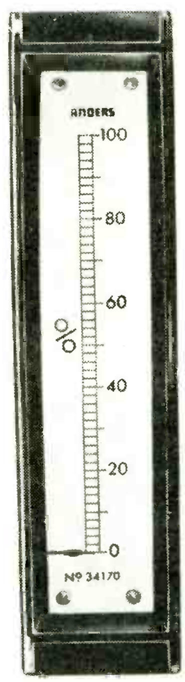


Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

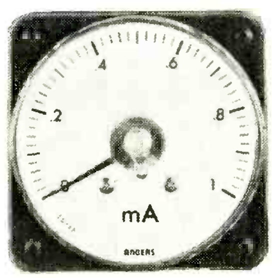
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.



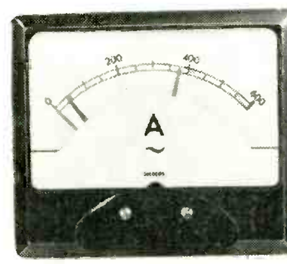
Vulcan Moving Iron. 4 models, 1·5″, 1·8″, 2·7″, 3·7″ scales. Voltmeters, ammeters and motor starting meters.



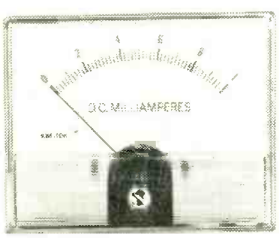
Profile 350 edgewise 4·3″ scale.
DC moving coil and AC moving coil rectified.
Horizontal or vertical mounting.



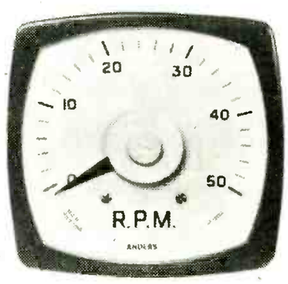
Oxford Long Scale 240°. 2 models, 5·5″, 8″ scales. DC moving coil and AC moving coil rectified.



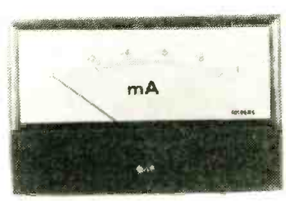
Solicontroller Moving Coil Relay. DC moving coil and AC moving coil rectified. 1 or 2 adjustable alarm controls.



Kestrel Clear Front. 7 models, 1·3″—5·25″ scales. DC moving coil, AC moving coil rectified, AC moving iron.



Stafford Long Scale 240° 6 models, 3·5″—11·5″ scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.



Regal Range 100° flattened arc. 2 models 2.5″ and 3.2″ scales. Taut band. DC moving coil and AC moving coil rectified.

Send for fully illustrated catalogue.

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Manufacturers and distributors of Electrical Measuring Instruments. Sole U.K. distributors of FRAHM Resonant Reed Frequency Meters and Tachometers. Manufacturers of purpose built electrical and electronic equipment to customers' requirements.

WW—015 FOR FURTHER DETAILS

RESISTANCE

JJ 'Point-One' Series Decades

Model	Range		Resolution	Tolerance	Price
Four-decade					
R3	0-1.111 ohms	Resolution	0.1 ohm	0.1%	£24.00
R4	0-11.110 ohms	..	1 ohm	0.1%	£24.50
R5	0-111.110 ohms	..	10 ohms	0.1%	£25.00
Five-decade					
R7	0-1.111,100 ohms		10 ohms	0.1%	£29.25
R9	0-111.110 ohms	..	1 ohm	0.1%	£29.75
R10	0-11.111 ohms	..	0.1 ohm	0.1%	£30.25
R11	0-11.111.000 ohms	..	100 ohms	0.1%	£34.50
Six-decade					
R20	0-1.111.110 ohms	..	1 ohm	0.1%	£36.00
R21	0-111.111 ohms	..	0.1 ohm	0.1%	£36.50
R22	0-11.111.1 ohms	..	0.01 ohm	0.1%	£40.00
Seven-decade					
R30	0-11.111.110 ohms	..	1 ohm	0.1%	£46.00
R31	0-1.111.111 ohms	..	0.1 ohm	0.1%	£42.50
R32	0-111.111.1 ohms	..	0.01 ohm	0.1%	£43.00
Eight-decade					
R41	0-11.111.111 ohms	..	0.1 ohm	0.1%	£52.00
R42	0-1.111.111.1 ohms	..	0.01 ohm	0.1%	£49.00

JJ 'Hundred' Series Precision Decades

Model	Range		Resolution	Tolerance	Price
Four-decade					
R400	0-111.100 ohms	..	10 ohms	0.03%	£44.00
R401	0-11.110 ohms	..	1 ohm	0.03%	£46.00
R402	0-1.111 ohms	..	0.1 ohm	0.03%	£47.00
R403	0-111.1 ohms	..	0.01 ohm	0.03%	£50.00
Six-decade					
R600	0-11.111.100 ohms	..	10 ohms	0.03%	£60.00
R601	0-1.111.110 ohms	..	1 ohm	0.03%	£61.00
R602	0-111.111 ohms	..	0.1 ohm	0.03%	£62.00
R603	0-11.111.1 ohms	..	0.01 ohm	0.03%	£65.00
Seven-decade					
R701	0-11.111.110 ohms	..	1 ohm	0.03%	£71.00
R702	0-1.111.111 ohms	..	0.1 ohm	0.03%	£72.00
R703	0-111.111.1 ohms	..	0.01 ohm	0.03%	£75.00

JJ High Dissipation Decades

Model	Range		Resolution	Tolerance	Price
HD1	0-1,111,100 ohms	..	10 ohms	1%	£52.00
HD1/L	0-111.110 ohms	..	0.1 ohm	1%	£55.00

CAPACITANCE

JJ Decade

Model	From	To	Tolerance	Price
C3 }	100 pF	0.111 μF	1%	£23.50
PC3 }			0.5%	£33.25
C4 }	100 pF	1.111 μF	1%	£37.00
PC4 }			0.5%	£51.00
VC4	50 pF	0.11115 μF	1%	£31.00
VC5 }	50 pF	1.11115 μF	1%	£45.00
PVC5 }			0.5%	£75.00

JJ Precision Decades

Model	From	To	Tolerance	Price
C500	50 pF	1.11105 μF	0.2%	£150.00
SVC5	50 pF	1 μF	0.05%	£249.00

JJ Variables

Model	Range		Tolerance	Price
Air Spaced Capacitors				
VC1	10 pF	260 pF	1%	£12.75
VC2	20 pF	1150 pF	1%	£23.50
Precision Air-spaced Capacitors				
PVC1	5-50 pF, 15-105 pF, 30-200 pF		0.5%	£65.00
PVC1/S	20-120 pF		0.5%	£36.00
PVC2	20-1.100 pF		0.5%	£50.00
Incremental Air-spaced Capacitor				
PVC4	0-1 pF. 0-10 pF		1%	£38.00

JJ Switched Capacitance

Model	Range	Tolerance	Price
C60 }	0.1 μF-61 μF	5%	£62.00
C60P }		1%	£117.00
C100	1 μF-100 μF	5%	£68.25
C140	1 μF-140 μF	5%	£79.00

INDUCTANCE

JJ Decades

Model	Decades	From	To	Tolerance	Price
L1	3 - decade	1 mH	1.11H	5%	£41.00
L2	2 - decade	1 mH	110mH	5%	£29.25
L3	2 - decade	10mH	1.1H	5%	£33.00
Precision Decades					
L300	3 - decade	1 mH	1.11H	0.3%	£150.00
L400	4 - decade	1 mH	11.11H	0.3%	£200.00

JJ 'Junior' Series

RESISTANCE

Model	Range		Resolution	Tolerance	Price
Three decade					
J5	0- 11.100 ohms	Resolution	10 ohms	1%	£9.95
J6	0- 1.110 ohms	..	1 ohm	1%	£9.90
Four-decade					
J3	0- 111.110 ohms		10 ohms	1%	£12.40
J4	0- 11.110 ohms	..	1 ohm	1%	£12.20
Five-decade					
J1	0-1.111.100 ohms	..	10 ohms	1%	£15.60
J2	0- 111.110 ohms	..	1 ohm	1%	£15.40
Six-decade					
J60	0-1.111.100	..	1 ohm	1%	£18.90
Seven-decade					
J70	0-11.111.110	..	1 ohm	1%	£22.50

CAPACITANCE

Model	Range	Tolerance	Price
JC1	100 pf-11.100 pf	1%	£12.90
JC2	30 pf-11.140 pf	1%	£13.70

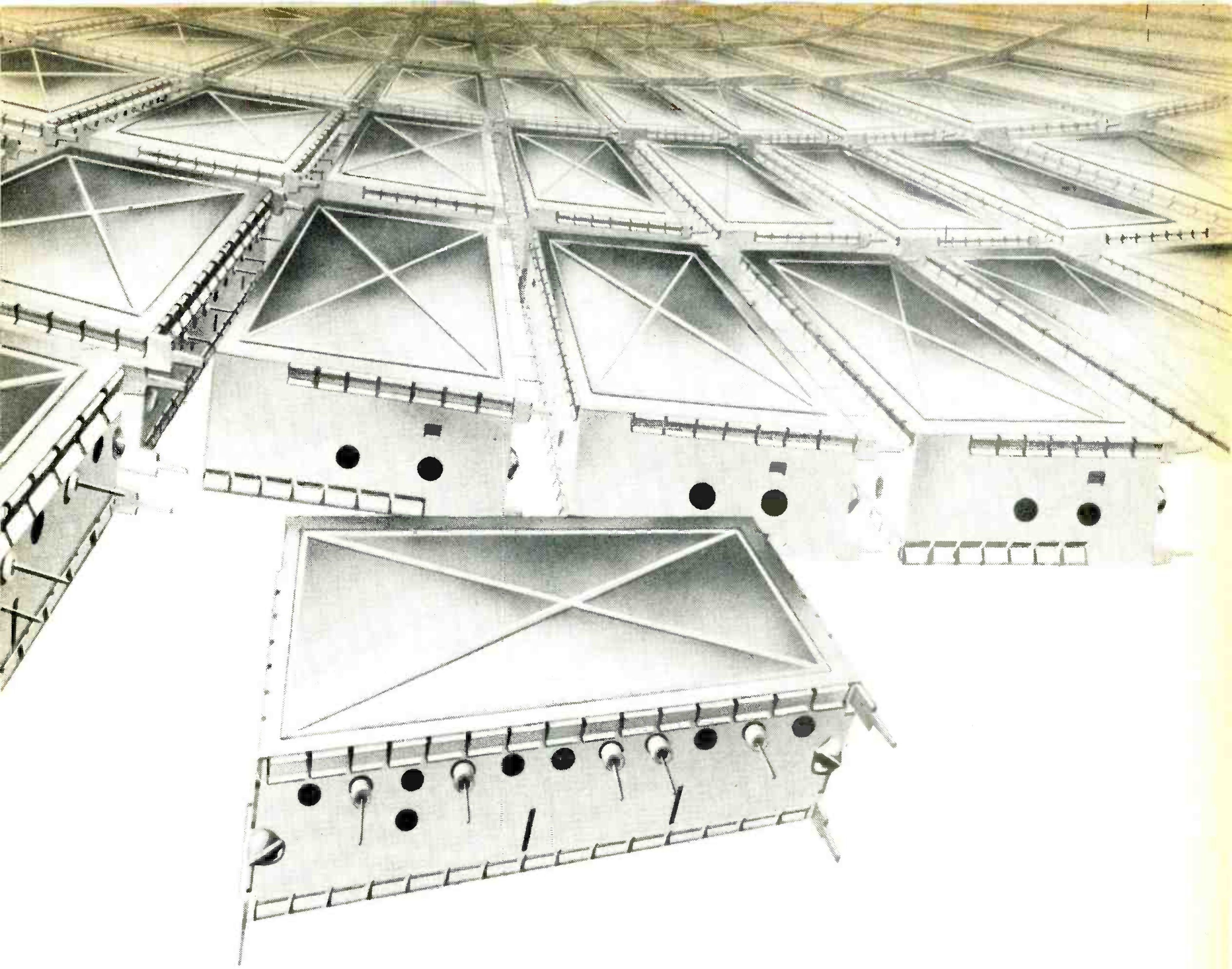
All tolerances shown are nominal and refer to major decades at 20°C

JJ INSTRUMENTS

J.J. Lloyd Instruments Limited
Brook Avenue, Warsash, Southampton SO3 6HP.
Tel: Locks Heath 4221

I.L.E.C.S. EXHIBITION STAND No. 721

WW—016 FOR FURTHER DETAILS



now in quantity production at Mullard, Thornaby

a considerably reduced noise level; far greater reliability and it replaces outdated electromechanical tuning systems.

For the stylist there are new freedoms; the tuner can be sited practically anywhere on the set, it's a great deal smaller, and the buttons have a feather-like feel.

'Varicaps' are coming off the production line at the Mullard Thornaby plant at the rate of many thousands a month. And increasing.

Thornaby–yet another important 'component' in Mullard's massive investment in colour television, helping to increase an already imposing export performance. And helping you to produce the finest, most up-to-date, colour sets in the world.

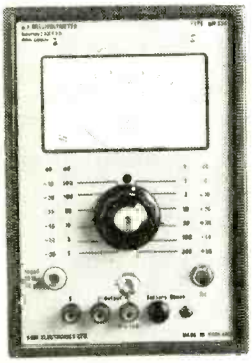
In quantity and quality. For today and tomorrow from Mullard Limited.

Mullard

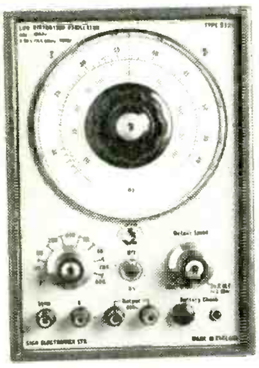
M39

Rogers Audio Test Equipment.

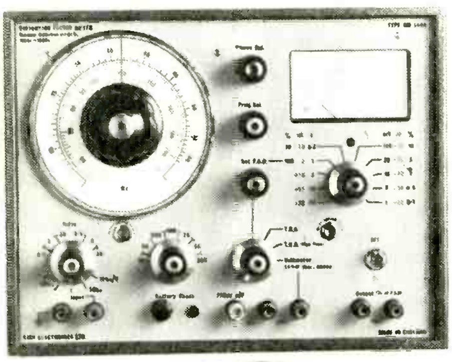
A comprehensive, versatile range of test equipment primarily designed for the measurement of high quality audio equipment, but with additional applications in the electronics industry in general. The equipment is of particular interest to the professional audio engineer, recording studios, broadcasting authorities, and educational establishments.



Type AM324 AF Millivoltmeter. Designed for voltage measurements in the audio and low R.F. ranges and, principally for measuring low level signals in high impedance circuits. An additional application is as a pre-amplifier in conjunction with the DM344A Distortion Factor Meter for the measurement of distortion of millivolt signals. Voltage Range: 1mV. to 300V. F.S.D. in 12 ranges. Frequency Response: 10 Hz to 500 kHz. Input Impedance: 10 megohms and 20 pF. for all ranges. Oscilloscope Output: Nominal 1 volt, output impedance 5K. Available for battery operation or with regulated mains power unit. Supplied in chassis form for rack mounting or in free-standing bench case. **Recommended Selling Price: Chassis — £64.00. c/w Case — £70.00.**



Type S324 Low Distortion Oscillator. Generates a pure sine wave and has been designed as a general purpose low distortion signal source. The primary application, used in conjunction with the DM344A Distortion Factor Meter, is the measurement of distortion on high quality audio amplifiers, recording and transmission equipment. Frequency Range: 6 Hz to 60 kHz. in eight third-decade bands. Accuracy ± 3% 20 Hz to 20 kHz. Output Amplitude: Within ± 0.5 dB 20 Hz to 20 kHz. Distortion: Less than .05% 100 Hz to 10 kHz. Less than .12% 20 Hz to 20 kHz. Available for battery operation or with regulated mains power unit. Supplied in chassis form for rack mounting or in free-standing bench case. **Recommended Selling Price: Chassis — £56.50. c/w Case — £62.50.**



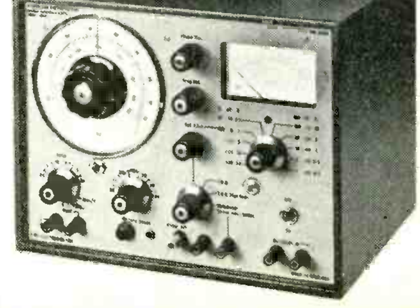
Type DM344A Distortion Factor Meter. Designed to make accurate and rapid measurements of total harmonic distortion generated within high quality audio amplifiers, recording and transmission equipment. The instrument is direct reading and indicates the total harmonic content of a complex waveform in R.M.S. values expressed as a percentage of the total. Frequency Range: 20 Hz — 20 kHz for fundamental in six third-decade bands. Total Harmonic Distortion Range: 100% F.S.D. to 0.1% F.S.D. in 7 switched ranges. Voltmeter Range: 30V – 1mV F.S.D. in 10 ranges. Instrument Residual Distortion: Less than 0.01% 100 Hz to 10 kHz. **Recommended Selling Price: Chassis — £132.50. c/w Case — £140.00.**

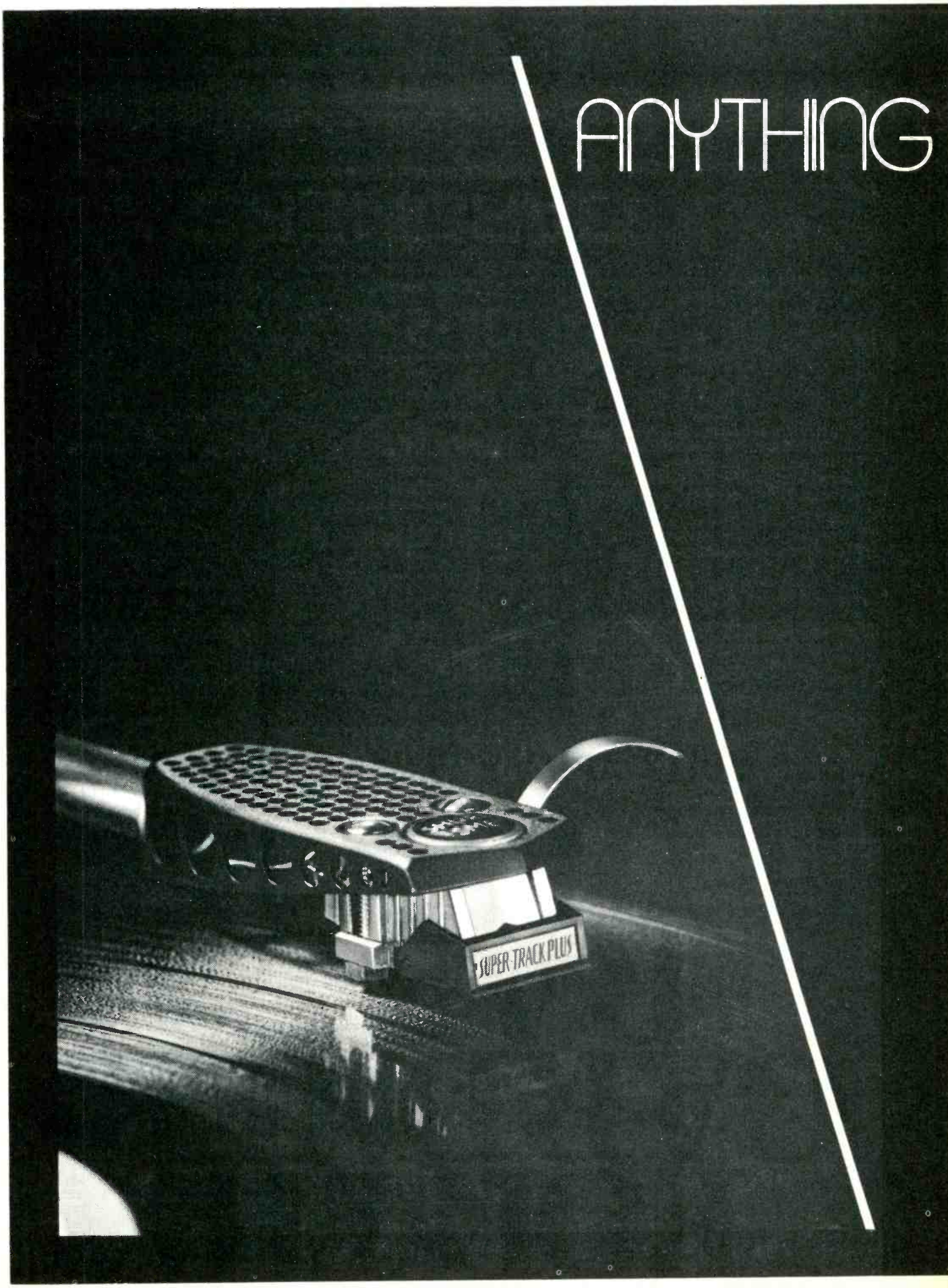
Model A Noise Generator. A portable battery operated unit designed for carrying out listening tests on loudspeakers. "Pink" or "White" noise can be selected and output can be continuous or burst. Output is continuously variable. **Selling Price: £32.50.**

Rogers Developments (Electronics) Limited.
4/14 Barmeston Road, London, SE6 3BN. Telephone: 01- 698 7424/4340.

Please send me colour literature describing your complete range of Audio Test Equipment.

NAME .... POSITION ....
COMPANY ....
ADDRESS ....




ANYTHING
SUPER-TRACK PLUS

A Garrard deck-ask the man who owns one

◀AP76 module: this superb deck offers every modern feature you need for Hi-Fi performance. This is a genuine transcription quality deck at a moderate price
Fitted with 75/6/SM Shure cartridge.

AP96 module: the connoisseur's single playing transcription deck. It is beautifully styled with precision performance to match any Hi-Fi system.
Fitted with 75/6/SM Shure cartridge.

Make no mistake—your deck is the key unit in your Hi-Fi equipment. All the latest electronic refinements in amplifiers and speakers can be wasted if the deck is not precision-built and mechanically reliable. Ask the man who owns a Garrard. He may take it for granted—but that's the way it should be. You have no second thoughts, no regrets once you've bought Garrard. That's why the overwhelming majority of 'package deals' start with a Garrard. Hi-Fi dealers can't afford after sales problems, so they go for Garrard.
Go along with your dealer—go for Garrard.

SP25 Mk III module: this automatic single play deck offers the refinements of enthusiast Hi-Fi at a budget price.
Fitted with 75/6/SM Shure cartridge.

ZERO-100S module: the ultimate. Tangential pick-up arm virtually eliminates tracking error. The transcription turntable with the greatest combination of advanced features available today.
Fitted with M93/E Shure cartridge.

These Garrard units are supplied complete with elegantly styled bases and distinctive lift-off hinged covers, which can be closed during playing. Ready-wired for quick and easy connection to mains and amplifier.

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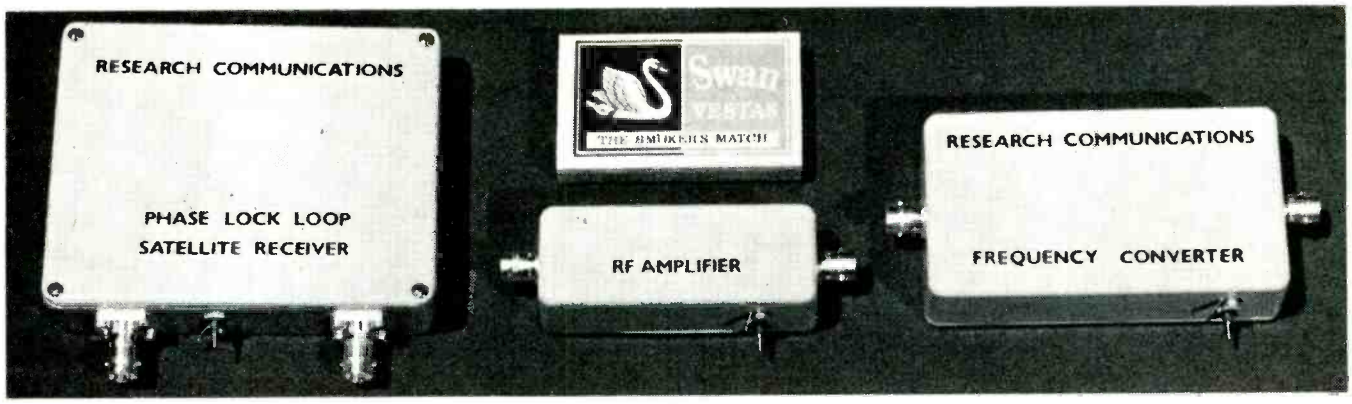
Please send me more details on the Garrard range of modules and decks.

Name ____________________
(Block letters)
Address ____________________

Garrard
A PLESSEY QUALITY PRODUCT

To: Garrard, Dept.WW, Newcastle Street, Swindon, Wiltshire.

WW—023 FOR FURTHER DETAILS



PHASE LOCK LOOP RECEIVERS

Type 1100 Satellite Band. 135-140 MHz.
1.5 dB. Noise Factor. High system gain. Automatic search and lock facility tunes receiver to satellite transmission in range without manual adjustment and enables several satellites to contribute to picture print-out without operator involvement over an extended period. Single channel or manual operation may also be selected. The unit is designed and rated for continuous duty monitoring service. The output drives facsimile picture equipment directly. £250

Type 1200 Telemetry. 95-105 MHz.
AM, FM, multiplex FM, pulse. Automatic signal tracking and locking. £250
Type 1201 410-420 MHz £330
Type 1300 Single or Multichannel. AM, FM, multiplex FM, FSK, RTTY. Up to 250 MHz £240
Type 1301 250-470 MHz £320

Type 1400 Radiometer. Type 1450 Interferometer.
Broadband response with maximum usable sensitivity. 81.5 MHz & 151.5 MHz £230
The DC output drives up to two pen recorders. 408 MHz £300

Receiver size: 4½" x 3½" x 1½". Aluminium diecast case.

FREQUENCY CONVERTERS

Type 1050 Input frequency as specified in the range 1 to 250 MHz. £60
Type 1060 Input frequency as specified in the range 200 MHz. to 700 MHz. £80
Size: 4½" x 2½" x 1½". Aluminium diecast case.

RF AMPLIFIERS

Type 1010	LOW NOISE FET RF PREAMPLIFIERS	
Frequency:	As specified in the range 1 to 250 MHz.	
Bandwidth:	As specified from 1% to 10% of centre frequency.	
Noise Factor:	1.5 dB @ 150 MHz.	
Gain:	35 dB @ 100 MHz. Adjustable	£40
Type 1011	LOW NOISE RF/IF AMPLIFIERS	
Frequency:	30 MHz., 60 MHz., or as specified in the range 1 to 150 MHz.	
Bandwidth:	As specified from 1% to 20% of centre frequency.	
Noise Factor:	1.5 dB. @ 60 MHz.	
Gain:	65 dB. max. Adjustable −60 dB.	£60
Type 1040	WIDEBAND AMPLIFIER to 100 MHz.	
Gain:	45 dB. ± 1 dB. 1 Hz. to 100 MHz.	
Gain Control:	120 dB. Manual or AGC.	
Noise Factor:	5 dB. @ 40 MHz.	£50

Types 1010 to 1040. Size: 3½" x 1¼" x 1¼". Aluminium diecast case.

V.A.T. applicable at the current rate excepting export orders.

For further information telephone Mr. P. H. Strudwick, Faversham 2064
Illustrated brochure available on request.

RESEARCH COMMUNICATIONS

PEEL HOUSE, PORTERS LANE, OSPRINGE, FAVERSHAM, KENT. ME13 0DR Telephone: Faversham 2064

WW—024 FOR FURTHER DETAILS

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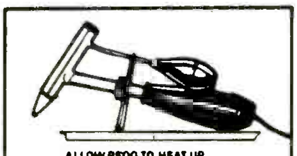
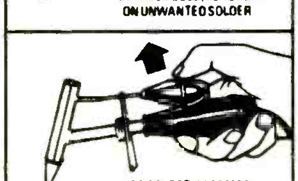
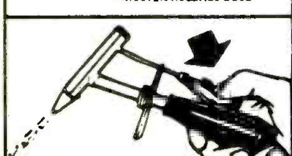
new! ADCOLA R500

ELECTRIC DE-SOLDERING INSTRUMENT


ALLOW R500 TO HEAT UP FOR ABOUT TWO MINUTES


DEPRESS BULB, PLACE BIT ON UNWANTED SOLDER


AS SOLDER BECOMES MOLTEN RELEASE BULB


TO EJECT OLD SOLDER SHARPLY DEPRESS BULB

Removes unwanted solder!

R500 is

PURPOSE DESIGNED NOT AN ADAPTION TO A SOLDERING IRON

NO AIR OR VACUUM LINES

ONE HAND OPERATION

ROBUST CONSTRUCTION

EASY TO USE

OVERALL DESIGN GIVES CLEAR VISION OF WORK PIECE

WELL BALANCED

TROUBLE FREE

ALL VOLTAGES AVAILABLE

Post now to ADCOLA

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REG. No. 442762 V.A.T. No. 235-6153-72

☐ Please send immediately an R500 De Soldering Instrument cheque enclosed for £6.72 plus 10% V.A.T. (postage paid U.K. only)
☐ Please send further details.
(Tick appropriate box)

NAME ....
ADDRESS ....
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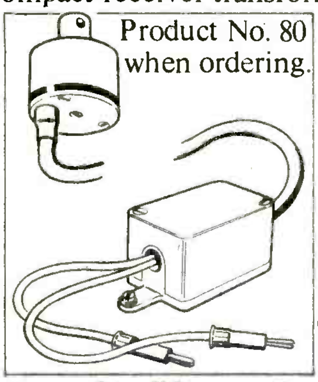
WW—025 FOR FURTHER DETAILS

With the Aerialite Mastatic System you wouldn't know you were in a difficult reception area

The **'Mastatic'** whip-type vertical rod aerial is made to be fixed high above electrical interference.

When it's used with the **'Antistatic'** system it returns superb performance in difficult reception areas.

The **'Antistatic'** (AM) has a frequency range covering all popular broadcast and short wave bands. It consists of a weatherproofed aerial transformer connected by 60 ft. of screened downlead to a compact receiver transformer.



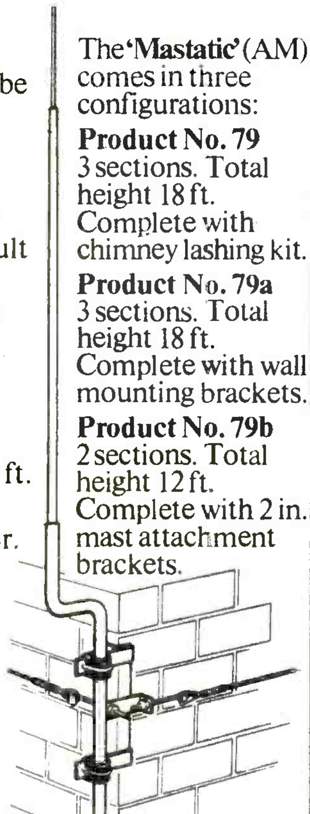
Product No. 80 when ordering.

The **'Mastatic'** (AM) comes in three configurations:

Product No. 79
3 sections. Total height 18 ft. Complete with chimney lashing kit.

Product No. 79a
3 sections. Total height 18 ft. Complete with wall mounting brackets.

Product No. 79b
2 sections. Total height 12 ft. Complete with 2 in. mast attachment brackets.



For full information please contact your local Aerialite Distribution Depot or write to:

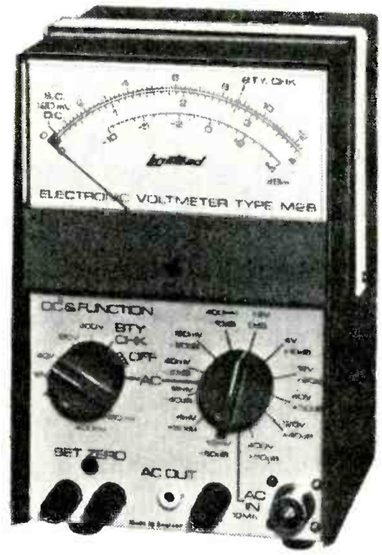
Aerialite Aerials Ltd

Radnor Park Trading Estate, West Heath, Congleton, Cheshire CW12 4PX. Telephone: Congleton 3892/8
Telegrams: Aerialheat, Congleton. Telex: 669640.

WW—031 FOR FURTHER DETAILS

NEW Linstead M2B

ELECTRONIC VOLTMETER



The M2B based on our well tried M2A has been completely redesigned mechanically with a vertical construction that takes only 5″ × 5″ of bench space. The carrying handle sits neatly on top of the instrument or may be used as a rest when operated in a sloping position. The A.C. frequency range is now 10 Hz to 1 MHz with amplifier output having a maximum gain of 600 times. A feedback circuit linearises the scales and readings start at 60 microvolts. Input impedance on A.C. and D.C. is 10 Megohms.

12 A.C. RANGES
10Hz to 1MHz
1.2mV FSD to 400V
-70dBm to +54dBm.
8 D.C. RANGES
120mV FSD to 400V.

FOR

£35 (+ V.A.T. where applicable).

Further details about the new Linstead voltmeter available upon request.

Linstead

means a good deal in electronics

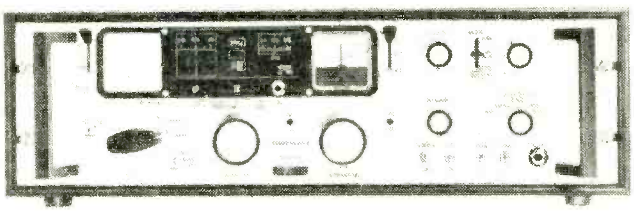
Linstead Electronics, Roslyn Works, Roslyn Road, London N15 5JB Telephone: 01-802 5144

WW—032 FOR FURTHER DETAILS

Eddystone Radio

Eddystone

EC958
series of receivers 10kHz to 30MHz In world-wide use



Professional high-stability receiver series for a wide variety of applications. The standard version can be used as a self-contained F.S.K. terminal, or as a dual-diversity terminal with common oscillator control. Variants are available for Lincompex terminal use, for specialized network monitoring surveillance and for marine applications.

Simplicity Reliability Economy

Your distributor's address and illustrated brochure obtainable from:

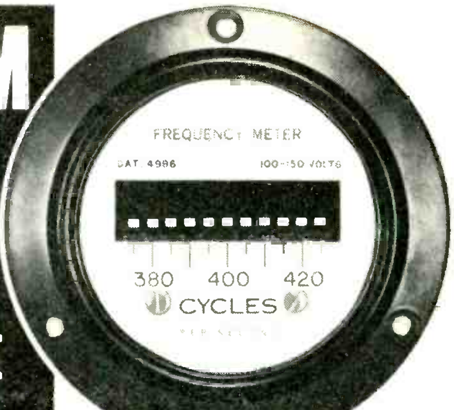
Eddystone Radio Limited
Alvechurch Road, Birmingham B31 3PP
Telephone: 021-475 2231. Telex: 337081

A member of Marconi Communication Systems Limited

LTD/ED99

WW—033 FOR FURTHER DETAILS

FRAHM resonant reed FREQUENCY METERS



used as standards in many industries

- Accurate to ±0.3% or ±0.1% as specified
- Not sensitive to voltage or temperature changes, within wide limits
- Unaffected by waveform errors, load, power factor or phase shift
- Operational on A.C., pulsating or interrupted D.C., and superimposed circuits
- Need only low input power
- Compact and self-contained
- Rugged and dependable

FRAHM Resonant Reed Frequency Meters are available in plastic and hermetically sealed cases to British and U.S. Government approved specification. Ranges 10–1700 Hz. Literature on these meters and Frahm Resonant Reed Tachometers available on request. Manufacture and Distribution of Electrical Measuring Instruments and Electronic Equipment. The largest stocks in the U.K. for off-the-shelf delivery.

ANDERS ELECTRONICS LIMITED

Anders means meters

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WW—034 FOR FURTHER DETAILS

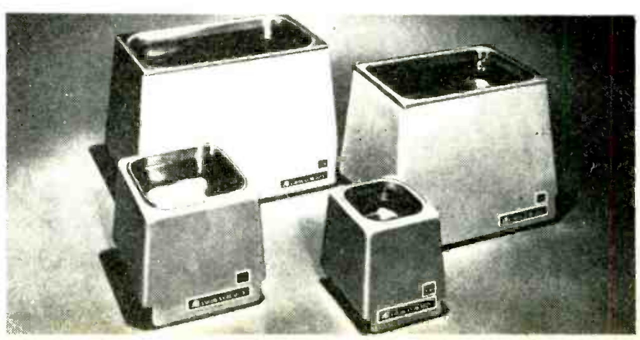
Bench size ultrasonic cleaners from American Beauty

Five new Ultrasonic cleaners which will clean items and assemblies that cannot be cleaned any other way. Cleans in minutes without scrubbing, rubbing or disassembly.

For example — suitable for electronic components and assemblies, intricate glassware, camera parts, lenses and other optical items.

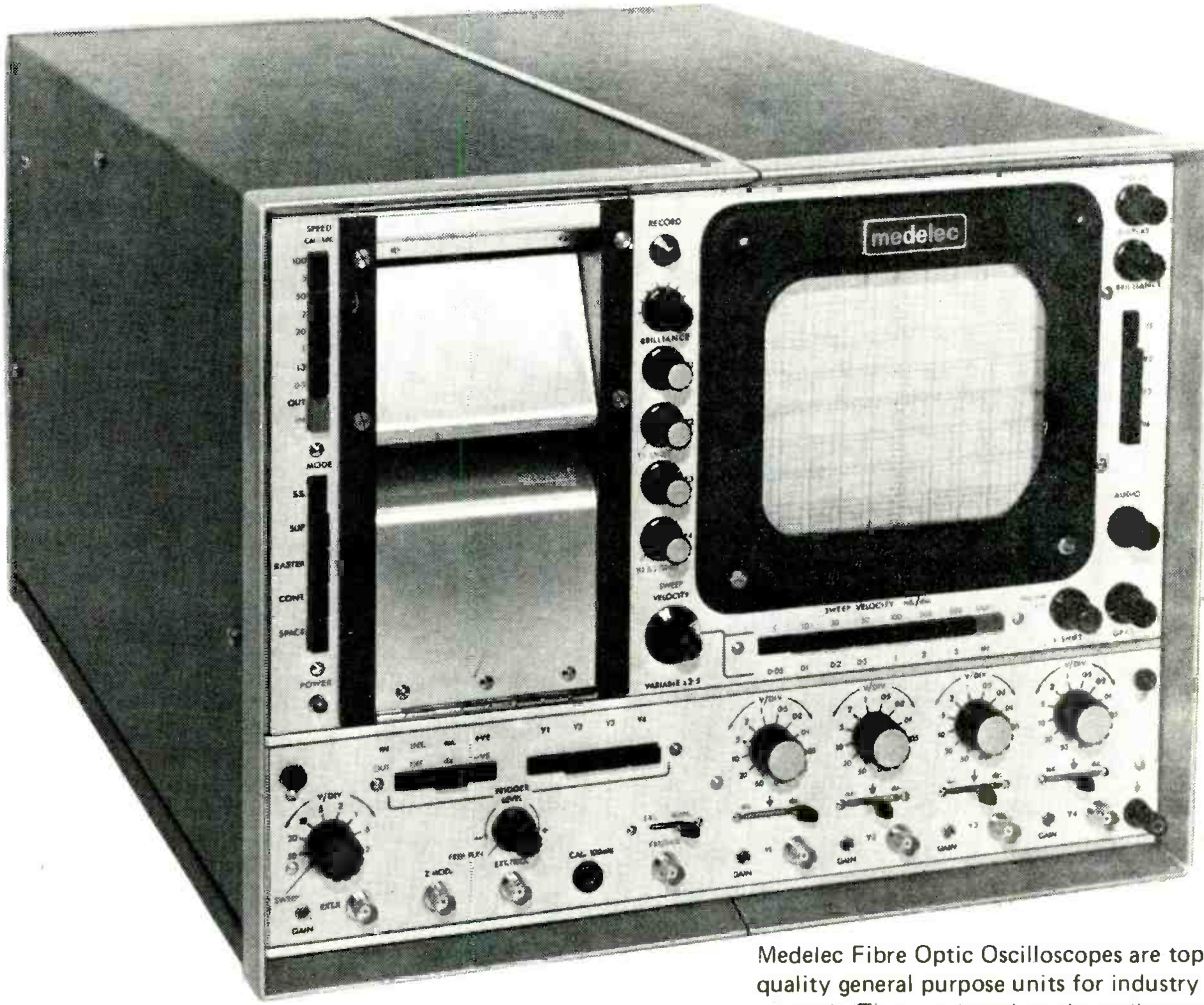
Cleans by means of high frequency sound waves — 50-55,000 cycles per second. Solid state circuitry. Completely self contained — NO EXTERNAL GENERATOR required. Portable — the smallest is a 5" cube. Largest capacity is 1 gallon (US). Virtually indestructible transducer. Long life — low cost.

Catalogue of cleaners, accessories and prices from:
Special Products Distributors Ltd., 81 Piccadilly, London W1V 0HL
Telephone: 01-629 9556.



WW—035 FOR FURTHER DETAILS

HERE'S WHY YOU SHOULD *NOT* BUY A U.V. RECORDER



Medelec Fibre Optic Oscilloscopes are top quality general purpose units for industry or research. They are based on the well proven techniques developed by Medelec in the exacting field of medical instrumentation.

- **HIGH QUALITY, LOW COST RECORDING**
- **SIMULTANEOUS RECORDING & VIEWING**
- **SINGLE FRAME OR CONTINUOUS RECORDS FROM A BUILT-IN CAMERA**

You will want to know more about the Medelec FOR-4 Fibre Optic Oscilloscopes—please contact us for detailed information or a personal demonstration.

FIBRE OPTIC

RECORDING OSCILLOSCOPES

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THE QUEEN'S AWARD TO INDUSTRY

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WW—041 FOR FURTHER DETAILS

Erie and Toshiba– an active components partnership

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A leading supplier of passive components now even more active with thick film hybrids.
Custom-designed, pre-packaged assemblies containing complete circuit functions. Miniature special law Cermet potentiometer, high voltage potentiometers and high power resistor assemblies. Produced at speed to exact specifications at competitive prices.

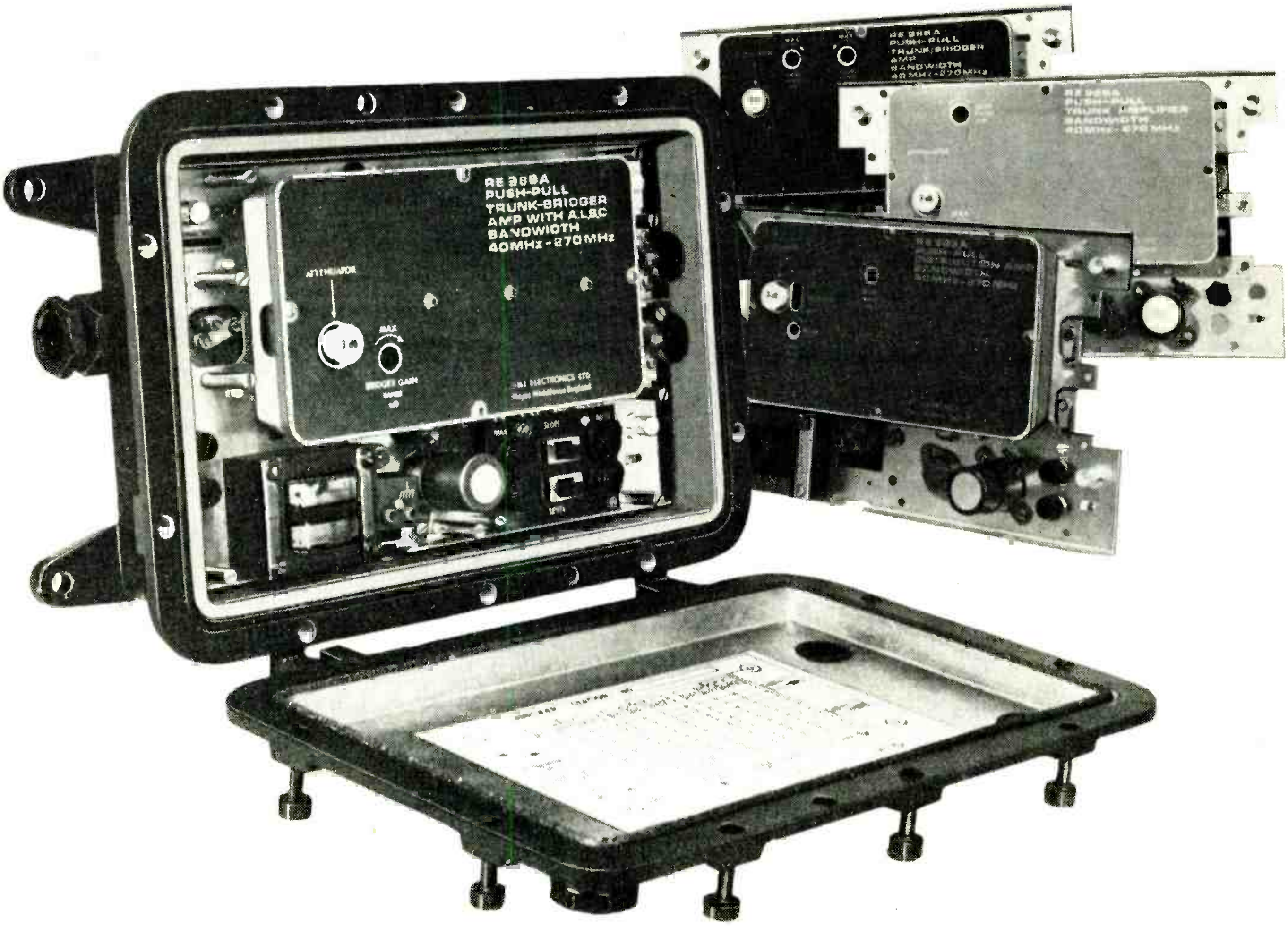
Take Toshiba

A world leader in power transistors – now with an even more impressive line-up of active components.
Giant Transistors up to 300 watts and 600 volts, high voltage devices up to 2200 volts. New L.E.D.'s for panel circuit indicators – advanced new devices featuring low drive power, high brightness visible red light emission, fast response time and a really compact package. Voltage regulators. Power thyristors and Trigger Diodes.
And behind Toshiba. Erie service: the most comprehensive, and certainly the most readily available, applications experience in the business.

Toshiba ERIE

ERIE ELECTRONICS LTD.
South Denes, Great Yarmouth, Norfolk.
Telephone: 0493 56122. Telex: 97421.

WW—045 FOR FURTHER DETAILS



EMI Colorline CATV

The multi-channel VHF system with 40-270 MHz bandwidth, lower distortion · Increased Cascadeability

EMI Colorline Mark II Push-Pull CATV equipment offers full channel capacity, lower distortion and greater system reach.
The push-pull amplifiers and their associated passive units have a band-width of 40-270 MHz and are designed for systems distributing up to twenty channels, where single octave operation is not acceptable.
VHF bands, 1,11, and 111 and areas of the VHF spectrum outside the normal broadcast bands can be used.
Mark II Colorline permits the planning and installation of networks having extremely low cross-modulation, intermodulation and harmonic distortion. All amplifiers have full AC line power facilities.
Amplifier/power units are readily interchangeable without disturbing cable connections and are also mechanically compatible with EMI Mark I amplifiers. If you're planning a CATV system, you should know more about Colorline. Contact EMI today.

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International leaders in
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EMI Telecommunications

Telecommunications Group,
EMI Sound & Vision Equipment Limited,
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Telephone: 01-573 3888 Telex 22417
Cables: EMISOUND LONDON

WW—046 FOR FURTHER DETAILS

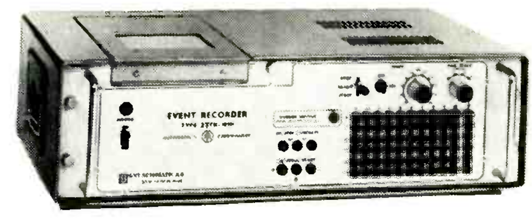
NEW PRODUCTS FROM COLE ELECTRONICS LTD.

A. P. CIRCUIT NOTCH FILTER

A new range of active notch filter modules for printed circuit board mounting. The 7-pin plug-in modules are available in a wide number of notch frequencies spanning the audio range within sharply defined limits. They eliminate line carrier and unwanted noise without distorting desirable frequencies.

COLE ELECTRONICS LTD.

WW—109 FOR FURTHER DETAILS



ELMI EVENT RECORDER

The Event Recorder ZTTK-10101 is a high-speed electric pulse recording instrument for simultaneous monitoring of up to 30 channels of on/off, go/no-go and other two-state data against time. The recorder produces a chart record of sequence, duration and time relationship of events occurring in the different channels.

COLE ELECTRONICS LTD.

WW—110 FOR FURTHER DETAILS

HARTMANN CODE SWITCHES

These switches have separate push-buttons for forward or backward setting and large easily legible numerals which remain fully visible during setting. The positive mechanism ensures that mid-positions and consequently falsely coded read-outs cannot occur.

Available in 3 Sizes	Front View	Figure Height
MHE (as Photo)	44 x 12mm	7.3mm
MICO	32 x 11mm	7.3mm
SMC	24 x 7.6mm	5.0mm

COLE ELECTRONICS LTD.

WW—111 FOR FURTHER DETAILS

RAF 1 CONTACTLESS SWITCHES

LATEST DESIGN USES HALL EFFECT INTEGRATED CIRCUIT. OPERATING ON 4.5V — 30V D.C., MAKING IT SUITABLE FOR MATCHING ALL TYPES OF LOGIC CIRCUITRY. RAF. 1 ARE ABLE TO SUPPLY ALL TYPES OF COMPLETE KEYBOARDS WITH ANY ESTABLISHED CODE STRUCTURE.

COLE ELECTRONICS LTD.
CHURCH ROAD, CROYDON CRO 1SG
TEL: 01-686 7581 TELEX: 262346

WW—112 FOR FURTHER DETAILS

FM TUNER

NELSON-JONES

Approved parts for this outstanding design (W.W. April 1971/2). Featuring 0·75 µV sensitivity. Mosfet front end. Ceramic I.F. strip. Triple gang tuning. ½V r.m.s. output level, suitable for phase locked decoder, as below. Designer's own P.C.B.

THOUSANDS NOW IN USE

FURTHER PRICE REDUCTIONS
Basic Tuner Parts with Screening Box.
NOW LESS THAN £11·50. Please send S.A.E. lists.

NEW ALIGNMENT SERVICE
Details on request.

SOLID STATE TUNING INDICATOR
(W.W. April '72). Tuning is indicated by the balance of two light emitting diodes. The kit includes, LED's, high gain transistors, P.C.B., resistors, mounting kit and instruction booklet. Order T041. Price £1·72 plus P. & P. 10p. with two LED's (or £1·98 with extra LED for "stereo" lamp-see decoder).

DIAL CHASSIS KIT
Now available—includes all dial drive components, dial plate, decoder mounting bracket, tuning scales, decoder-tuner tagstrips, etc., 4-way 2/3 pole rotary switch and instruction booklet. Price £2·15 plus P. & P. 17p (Note: may be purchased without dial drive components.)

PHASE-LOCKED STEREO DECODER KIT
Now with free LED "stereo on" light—complementing this superb decoder (W.W. Sept. '70). Suitable for wide variety of tuners including the NELSON-JONES TUNER.
Complete kit ONLY £7·68. P. & P. 16p.

NEW IC Stabilised PSU. S/C. overload protected, low ripple. £3·55. P. & P. 19p.

LIGHT EMITTING DIODES (Red)
Improved efficiency type, mech. identical to HP LED, panel or PCB mounting with *free* mounting clip—clear or black—please state. Order LED1A. Please add postage.
Monsanto miniature PCB mounting with radial leads. Order LED2. Please add postage.
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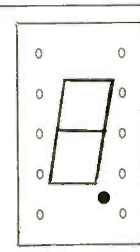

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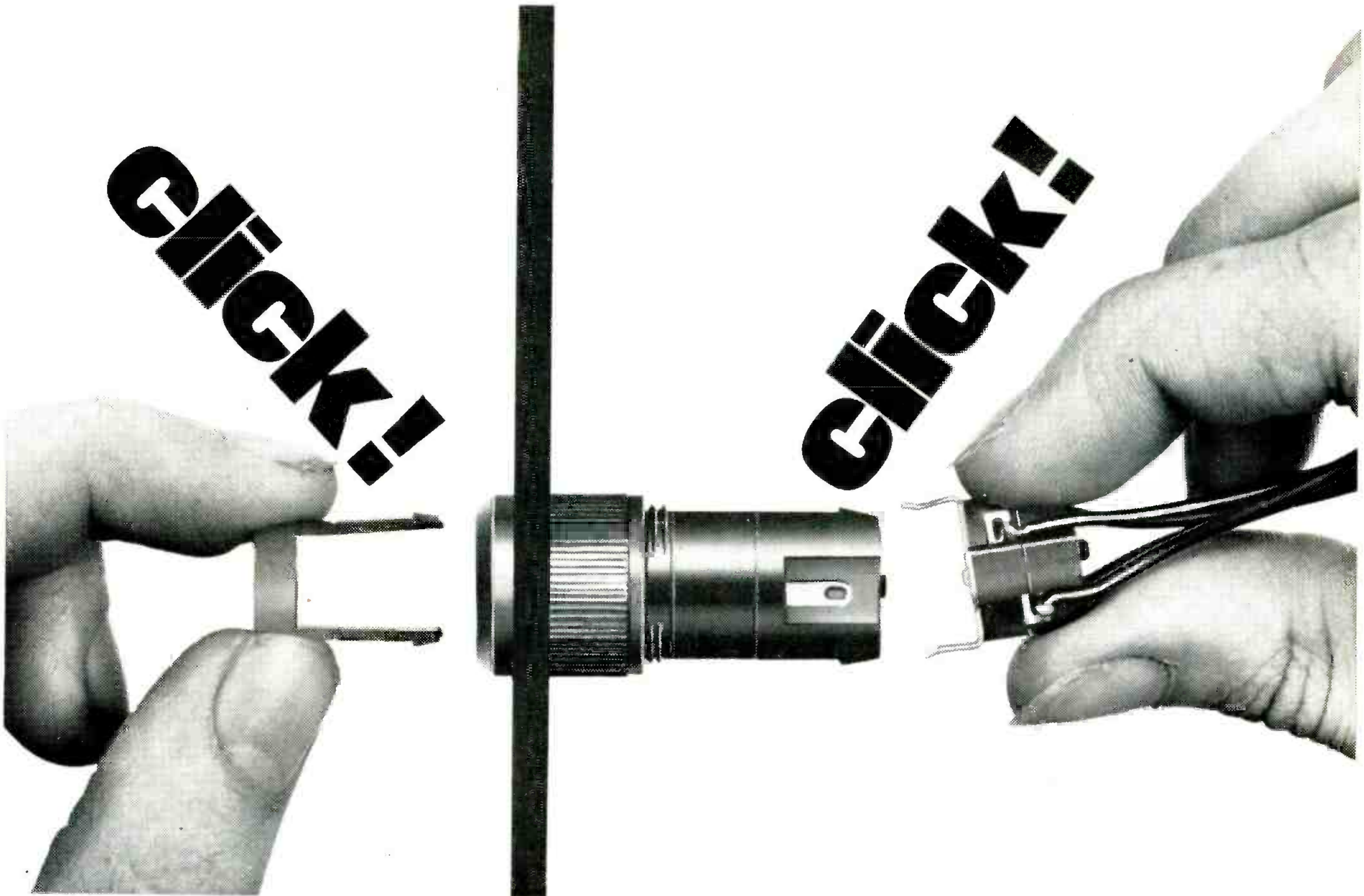

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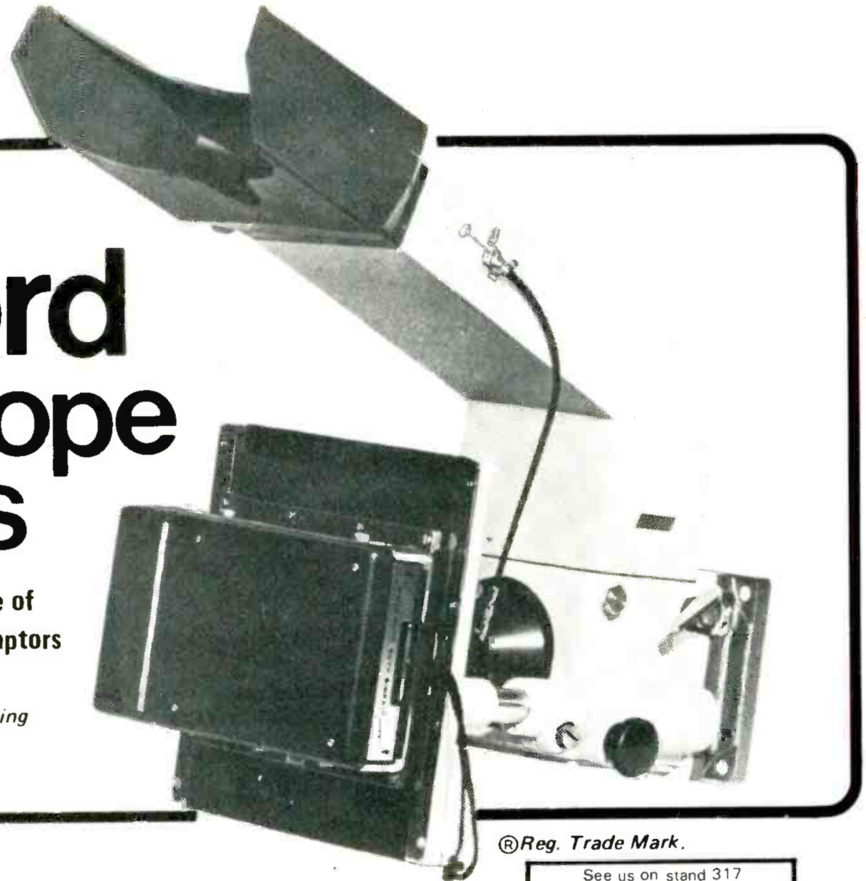

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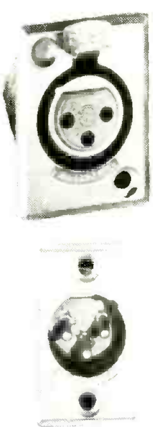

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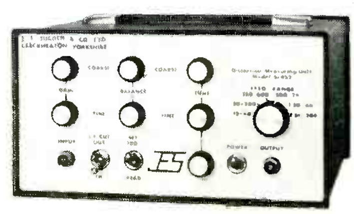

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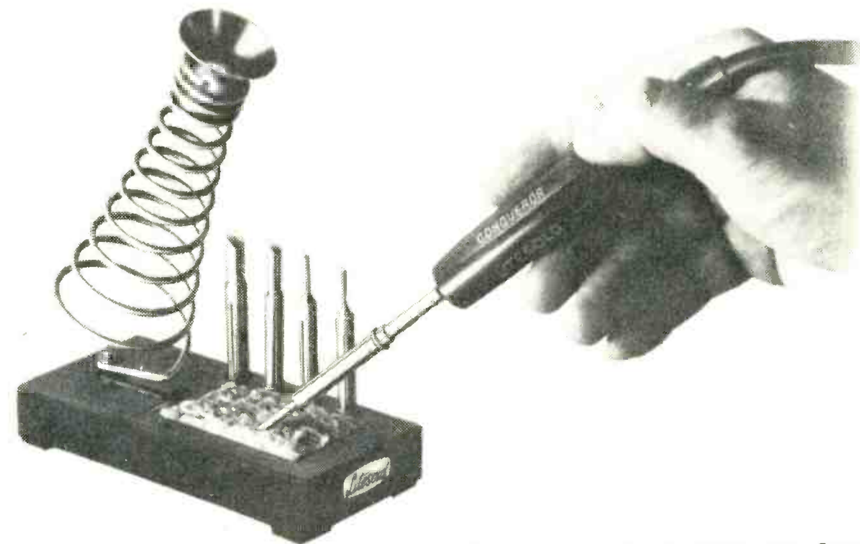

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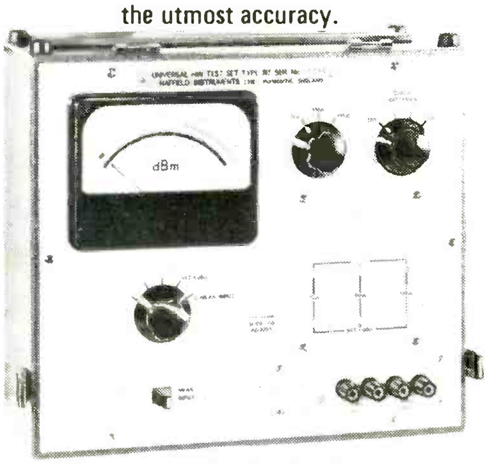

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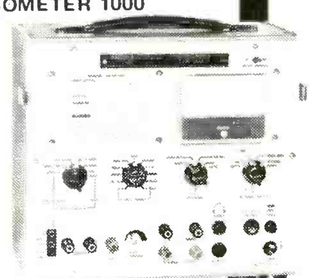

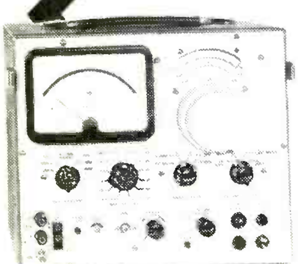

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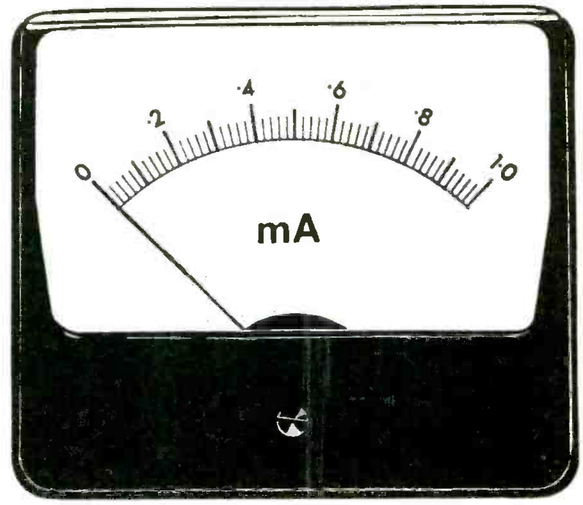

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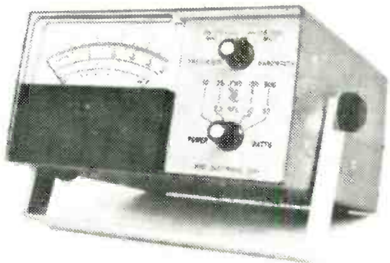

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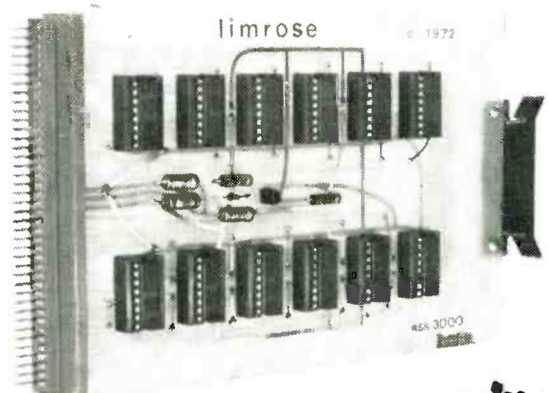

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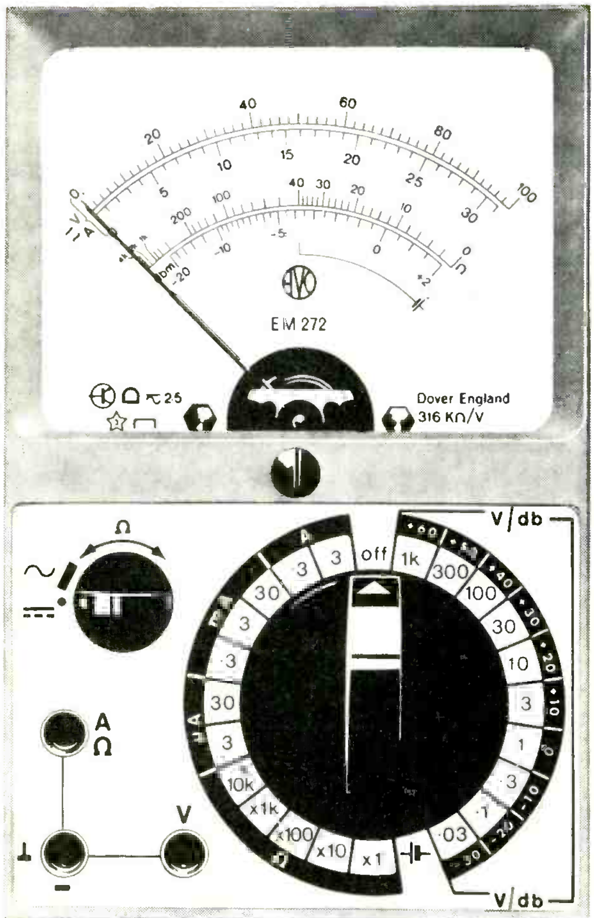

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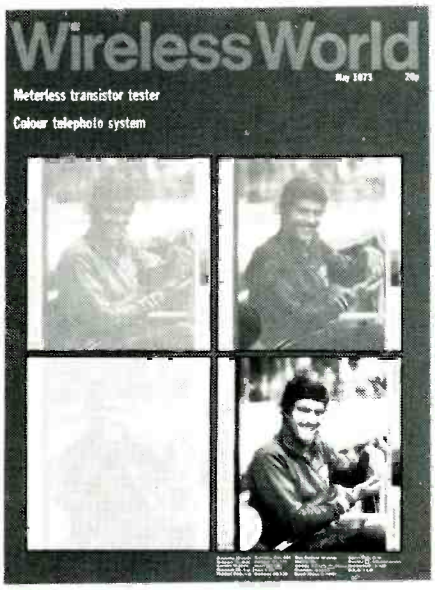

This month's cover shows four colour separations of a news picture sent by the colour telephoto system described by **J. H.** Smith in this issue (page 214).

Contents

In our next issue
(publication date May 21)

Varicap f.m. tuner. The variable capacitors in the Nelson-Jones tuner are replaced by varicap diodes to provide voltage controlled tuning. A lower gain modification is also described.

Microphone reflectors — a subject which has received little attention so far. This article examines the effects on frequency and polar response of reflector material, size, focal length and microphone size and position.

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Colour Telephoto System

News pictures electronically processed and transmitted as colour separations over telephone lines

*by J. H. Smith**, M.I.E.R.E.

By means of an extensive network rented from telephone authorities, news picture agencies can transmit pictures to subscribing newspapers. Picture facsimile is normally called "telephoto" and newspaper offices include a "telephoto room" in their communications department. Over the past three years IPC Technical and Information Services has been developing a system for sending colour pictures over the telephone networks and demonstrated the viability of the system by transmitting, in conjunction with the agency United Press International, colour pictures from the 1972 Olympic games in Munich.

Telephoto system. Fig. 1 shows how a photograph to be transmitted is loaded onto a rotating drum in a Muirhead picture transmitter. A synchronous motor supplied with a frequency of 1020Hz, divided down from a crystal oscillator, drives the drum.

*IPC Services Ltd.

As the drum rotates the picture is scanned. A photocell and light source are mounted behind the drum, and the photocell collects reflected light from the picture as the drum rotates. Stepping the photocell across the picture by 0.01 inch at the end of each line scan provides a frame scan. As pictures are normally 10 inches wide and there are one thousand scanning lines, the resolution of the system is 100 lines per inch. Since the system usually scans at a speed of one line per second a complete picture takes 1000 seconds transmission time—about twenty minutes altogether.

The video signal, which occupies a frequency band of 500Hz, modulates a 1300-Hz carrier, giving a double-sideband amplitude-modulated signal with a frequency range 800–1800Hz, well suited for transmission over telephone circuits. Since the system achieves synchronization before transmitting the picture, it is not necessary to transmit a synchronization signal along with the picture. In common with the transmitter, the receiver has a motor supplied with a frequency of 1020Hz driving the drum, but in this case a tuning fork generates the signal.

Immediately before transmitting a picture the operator sends his 1020Hz oscillator signal down the telephone line. The receiver operator then adjusts his tuning fork so that its frequency exactly coincides with that of the signal being received. The crystal oscillator and fork circuits are designed to keep stable within a fraction of a cycle for several hours. Thus the transmitter and receiver drums will rotate at exactly the same speed, even though the 1020Hz signal is removed from the line. The transmitter operator then transmits a phasing pulse which triggers a clutch mechanism linking the receiver drum to its drive motor. This pulse is obtained from a pair of contacts in the transmitter which close every time clips holding the picture on to the drum pass the photocell, thus synchronizing the start and finish of the transmitted picture to the receiver drum. After removing the phasing pulse the operator finally sends a white level reference signal, which enables the receiver operator to adjust his gain, thereby compensating for any attenuation or gain in the telephone circuits. Provided the telephone circuits remain stable the facsimile receiver will reproduce a faithful version of the picture wrapped around the transmitter drum.

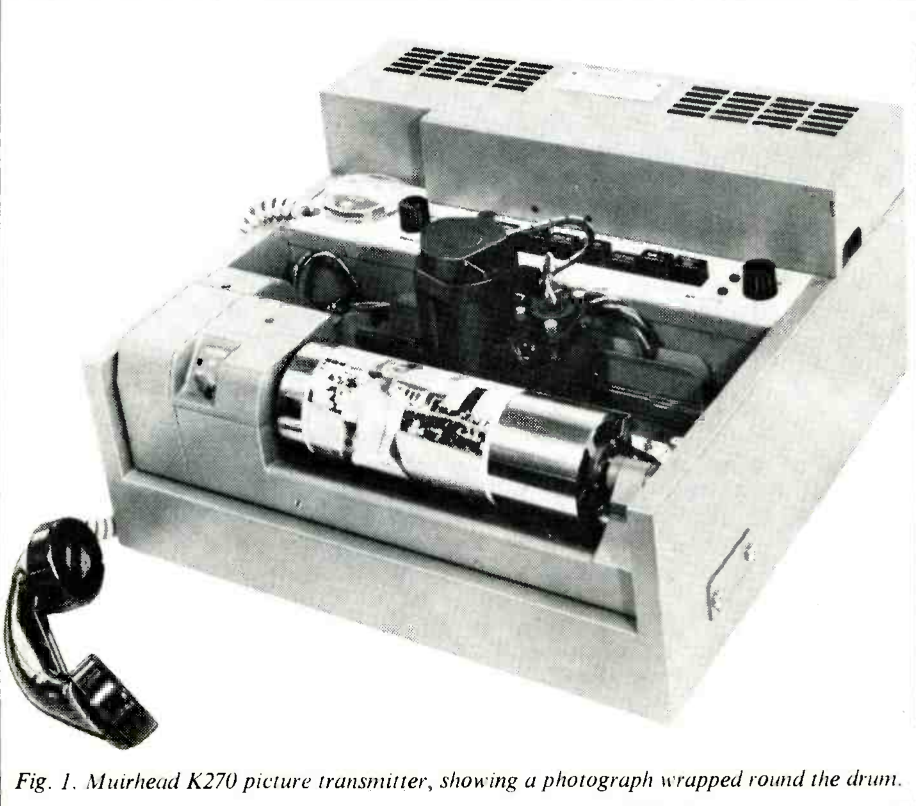


Fig. 1. Muirhead K270 picture transmitter, showing a photograph wrapped round the drum.

Printing by offset lithography. To gain a full understanding of the colour telephoto system we need a basic knowledge of the principles of colour printing. Since at present lithography is the technique the majority of newspapers use for printing in colour, I will concentrate on that process.

Irrespective of the printing process to be used, monochrome (black and white) photographs have to be processed after being enlarged or reduced into a form suitable for printing. The picture is broken into dots of various sizes—very small ones for the light grey areas of the photograph and much larger for the dark grey areas. Thus, instead of reproducing the black and white through various shades of grey, the picture is constituted by a matrix of dots of varying size. The eye spatially integrates over small areas so that we see various tones of grey. (Examine a newspaper or magazine picture through a magnifying glass.) The process of breaking the original photograph into a matrix of equally spaced dots is called "screening".

The screened negative is then made into a printing plate (usually aluminium) by etching a positive image of the picture onto the plate. "Image" areas of the plate accept the greasy ink and reject water, while non-printing areas of the plate accept water and reject ink.

In the offset lithographic process the printing plate is inked and the non-printing areas are kept free of ink by applying a watery solution. The printing machine then transfers the image from the plate to a rubber roller, called a blanket, and then from the blanket to the paper.

Colour pictures are reproduced by printing in turn images in four different colours. Thus a coloured newspaper picture usually comprises pictures printed in cyan, magenta, yellow and black. (Examine a coloured picture with a magnifying glass.) Here again spatial integration occurring within the eye, and the three colour receptors of trichromatic colour vision theory, produce sensations of tone and hue when one observes such pictures from a distance.

The colours used in colour printing are complementary to those used in colour television c.r.t. phosphors. This arises because television c.r.t. screen dots are primary sources of light, while coloured prints rely on reflected (secondary) light. Thus a colour television set generates white by energizing all three colour sources (black is the absence of light). One obtains white in a colour print by an absence of ink, and black by combining all three inks together.

Since cyan ink reflects blue and green light but stops red, while magenta ink reflects red and blue, stopping green, and yellow ink reflects green and red, stopping blue, a combination of two inks reflects only light reflected by both inks, as shown in Table 1.

Table 1

	red light	green light	blue light
cyan ink	stops	+	+
magenta ink	+	stops	+
yellow ink	+	+	stops

Thus cyan plus magenta reflects blue,
magenta plus yellow reflects red,
cyan plus yellow reflects green.
Cyan, magenta and yellow together give black—no reflected light.

A whole gamut of colours is reproduced by printing various proportions of the constituent colours. Black ink is normally needed in colour printing because the three inks together do not produce a very good black.

Colour telephoto

Since any colour telephoto system must produce a set of four different monochrome pictures for reproduction in colour newspapers, let us consider how this can be achieved with the telephoto equipment currently available. Transmission of photographic separations has been tried experimentally, but is seldom fast enough to meet newspaper deadlines.

Making a colour transparency of a news event, which itself takes about two hours to produce from the time the photographer opens the shutter to the time the process department delivers the finished transparency, is the first step in the colour reproduction process. The next step involves separating the transparency into its red, green and blue components. One can achieve this by making negatives from the original by exposing it through red, green and blue filters. One subsequently uses these three negatives to make enlarged positive bromide prints and transmit them one by one over the telephoto network.

Unfortunately the colour pictures printed from the red, green and blue separations produced in this time-consuming process are unsatisfactory because of colour imperfections in the inks, transparency and separation filters. One can overcome these defects by introducing an intermediate process to correct the colour separations (and the black overprint). This intermediate stage of colour correction is called "masking". I will discuss it in more detail later when I describe its electronic analogue. Because of the extra stages involved in preparing the components of a colour picture for press (as compared with a conventional black and white photograph) one can easily miss the deadline required by newspapers. Furthermore, an editor who wants to be able to publish colour news pictures must be prepared to finance extensive facilities for colour processing near to all possible news centres. The IPC colour telephoto system is designed to eliminate as many of these process stages as possible.

The foregoing dictates the specification of a colour telephoto machine for newspaper use:

- The machine must be compatible with the existing telephoto network.
- The machine must transmit to existing telephoto receivers.
- The transparency must be scanned directly and automatically enlarged to the standard 10in × 11in telephoto size.
- Colour correction must be automatic, so that the received pictures are ready for processing.
- The machine must reproduce a black printing separation.
- The machine must be simple to operate for a person who will not see the results of his transmission.
- The system used must be capable of further development.

The IPC colour telephoto apparatus satisfies this specification in every respect.

Basic system

Fig. 2 shows the principal components of the facsimile system. Scanning lines are generated on the face of a cathode-ray tube, similar to those generated for a television picture. These scanning lines form a square which in practice does not look like a television raster, because the scanning spot travels much more slowly in the telephoto system. A lens focuses the light output from the raster onto the transparency so that the scanning spot of light traverses it line by line until the spot has scanned the whole picture.

A partly-silvered mirror collects a sample of the light from the c.r.t. and feeds it to a photocell, which drives a circuit designed to stabilize the brilliance of the light output. Without this circuit the light output will vary too much to obtain consistent results while scanning the picture.

The scanning spot is very small and is focused accurately on the transparency, so that the light output on the far side of the transparency varies in intensity in accordance with the picture content.

A condenser lens collects the light and feeds it to an optical filtering system which separates the red, green and blue components. A dichroic mirror, which reflects red light only, passing green and blue unaffected, feeds the reflected red light through a correcting Wratten filter to a photomultiplier tube. Similarly another dichroic mirror feeds reflected blue light to a second photomultiplier. The green light, minus red and blue, passes to a third photomultiplier.

The signal, occupying a time of one thousand seconds, is an analogue of the complete picture. Having obtained a signal analogue of the colour transparency, one can effect any desired mathematical operation upon it. This follows because electrical signals can be handled more easily and precisely than optical signals. For instance, any number of photographic correction "masks" can be built into the circuits.

The three signals pass from the photomultipliers to variable gain amplifiers, which modify the density range of the original to levels suitable for printing. After compression the three signals are fed to a colour computer, which simulates the photographic colour "masking" system. The colour corrected outputs then pass one by one to a telephoto transmitter.

The signals are transmitted sequentially over a standard telephone line and reconstituted into pictures at the receiver. The received pictures are the cyan, magenta, yellow and black separations required for printing.

Fig. 2 shows that the facsimile transmitter triggers the timebases. The triggering action ensures that the scanning spot traverses the correct part of the picture and is in synchronisation with the distant receiver. The deflection drive, fed by the timebases, is an amplifier driving the deflection coils of the c.r.t.

Optical system

Fig. 2 also shows a simplified layout of the optical system. Designing this system posed a number of problems because of the necessity to separate colours. The colour spectra of interest are 400–500 nanometres (blue), 500–600nm (green) and 600–700nm (red).

As the screens of standard cathode-ray tubes are predominantly green, the system must incorporate one with a phosphor containing red and blue components. The phosphor must also give adequate brightness, together with a very small scanning spot. Eventually we chose the "A" type phosphor, because this gives useful light output over the full range of 400–700nm. One of the better flying spot scanner tubes is used to resolve 1600 lines on 35mm film.

The main lens proved to be the most

critical component, because it has to resolve the very fine scanning spot equally well in the red, green and blue parts of the spectrum; and it has to give accurate focus over the entire colour range and pass as much light as possible. We had to design a special lens to meet this specification.

Fig. 2 also shows that dichroic filters separate the light output from the transparency. We could have used partly-silvered mirrors instead, but with the limited amount of light available from the c.r.t. phosphors, dichroics proved more suitable. Because dichroics are not selective enough on their own, we used Wratten filters for correcting the light collected by the photomultipliers.

The signal output levels from the photomultipliers differ, so we use variable gain amplifiers for adjusting the red, green and blue signals to the same level. Fig. 3 shows the spectral distribution of each of these three channels.

Timebases

The facsimile transmitter triggers the timebases to synchronize the scanner with the telephoto system. This triggering system is necessary to merge text, and other data on the telephoto transmitter drum, with the picture being transmitted. The operator loads a caption and general description of the picture onto the telephoto transmitter drum, together with reference densities, registration marks and colour identification. As each colour is transmitted sequentially, the operator has to change the colour identification before sending the signals representing each separation.

Telephoto is a "thousand line" system with stability requirements well in excess of those acceptable for television. The line timebase must be accurate to within a fraction of one thousandth of an inch from line to line. If not, edges, such as the brim of a hat, become ragged. Similarly, the system must maintain stability from picture to picture, so that when the four separations are printed on top of each other they are accurately in register.

Level monitoring

Highlight and shadow monitoring comprise an important part of the system. The engineer has to balance the three input photomultipliers using a monochrome picture, so that the grey components of a picture are reproduced grey and not some other colour. Once they are balanced, the operator does not touch the input amplifiers.

When printed the highlight detail of the picture must be correct even though the original may be a normal, dark or light transparency. In consequence the operator must adjust the scanning light output to compensate for various transparency densities. Because picture highlights may be coloured, the system maintains colour balance by adjusting tube brilliance until *one* channel gives a peak signal. If the highlight is white all three channels will peak at the same level; but if the highlight is coloured one or two of the channels will generate slightly lower strength signals to signify the need for a small quantity of ink in this highlight area. Similarly, the darkest shadow in a picture must be reproduced with solid ink, but because this shadow is not necessarily black, the operator adjusts the shadow control until *one* channel gives a *minimum* signal.

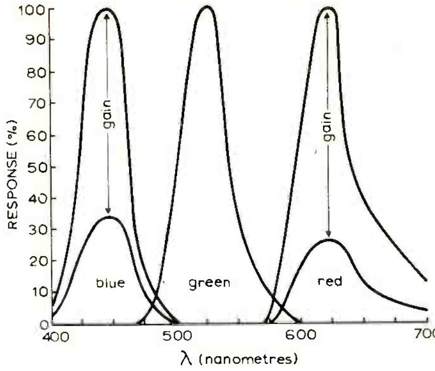


Fig. 3. Spectral distributions of the three channels.

The system adjusts for highlight and shadow density with the aid of a strobe consisting of a line scan, a potentiometer control to move it across the picture, and a meter to indicate the position of the strobe line on the transparency. The three monitoring meters, "highlight density", "strobe position", and "shadow density", are visible on the front panel shown in a photograph of the complete equipment on page 219.

The block diagram in Fig. 4 shows the principle used for metering circuits. The need for steady peak signal readings while using a one-second line scan complicated the circuits. Furthermore, the system must respond reasonably rapidly to highlight changes as the strobe line is moved across the transparency.

Fig. 4 shows how the trigger pulses are divided by two and gated to provide a pulse for every alternate line. These pulses discharge the capacitors of two peak detectors. The system employs two peak detectors, so that while one is charging to its peak the other is steady. By this means the peak detectors measure the peak on every alternate line. Outputs from the two peak detectors are combined, so that the meter displays a relatively steady reading.

In practice the system uses two peak detector pairs, one for the highlight and one for the shadow. Switching enables the meters to monitor various parts of the system for setting-up purposes. Field effect transistors employed in the peak detector circuits ensure the greatest possible accuracy of the readings obtained.

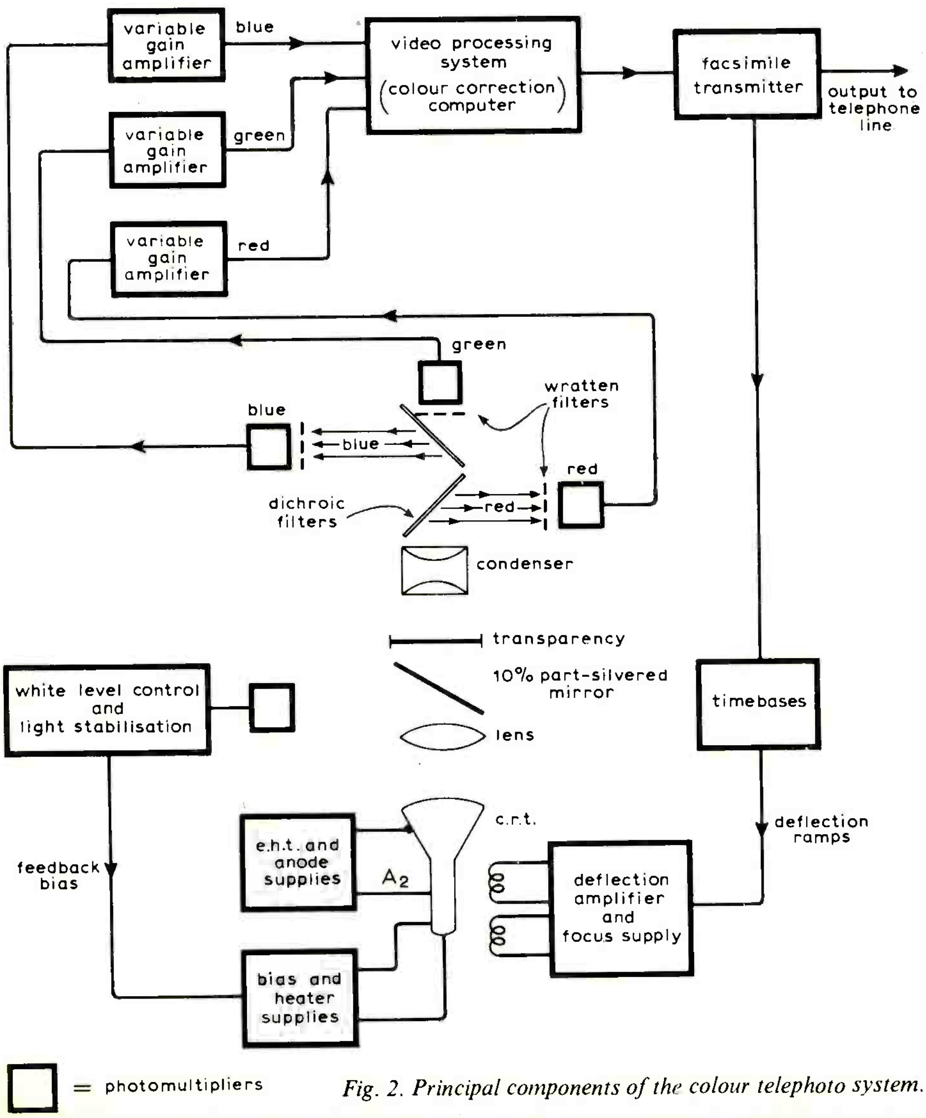


Fig. 2. Principal components of the colour telephoto system.

Photographic "masking"

Printing inks are not pure colours: each ink is effectively contaminated by the others. To simplify matters let us consider one error where magenta ink contains some

25 per cent of yellow. This means that wherever yellow and magenta inks are superimposed the resulting print contains an excess of yellow due to the presence of unwanted yellow in the magenta ink. As yellow and magenta reproduce red, the excess yellow will tend to make reds reproduce with an orange hue.

To correct this defect in conventional colour printing the operative makes a colour correcting "mask" by taking the *magenta* separation and making a low-contrast negative, 25 per cent of the original in this example. He then places this negative in accurate register over the *yellow* separation, so that whenever yellow is reproduced in magenta areas the contrast is *reduced* by 25 per cent. This means that less yellow is printed in those areas where magenta is also printed and the colours are reproduced accurately. The term "mask" comes from the fact that a low contrast negative is fitted over the positive, just like fitting a mask over the picture.

In practice "masking" is more complicated than I have described, because every colour of ink is effectively contaminated by every other colour.

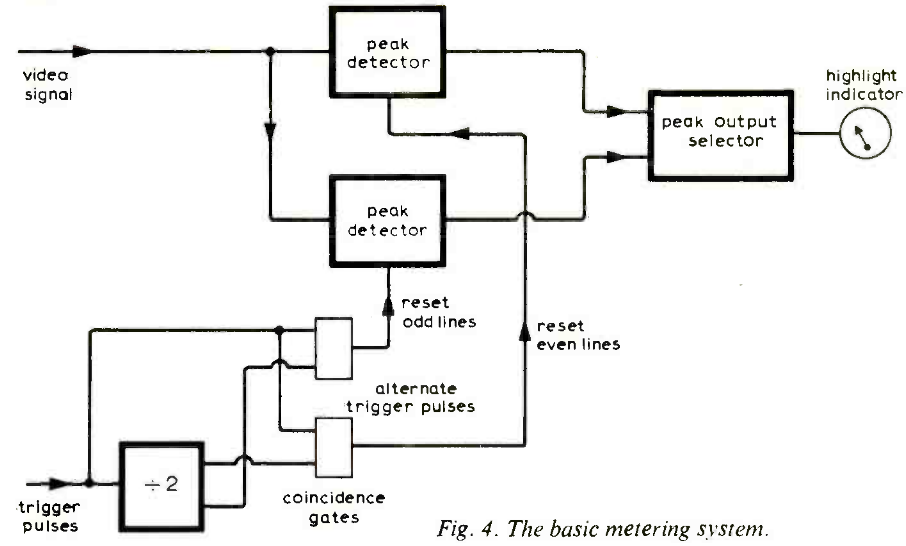


Fig. 4. The basic metering system.

Video processing

Fig. 5 shows the video processing system. The red, green and blue signals pass from the photomultiplier amplifiers to 2 decade loggers. These loggers form the first compression stage in the system, because this circuit crushes densities greater than 2.0. As indicated on the diagram, passing through the loggers transforms transmittance into density. Density is defined as:

$$D = \log_{10}\frac{1}{T}$$

Density is analogous to decibels in electrical terms. Since by definition clear film has a transmittance of one (100 per cent transmission), it consequently has zero density.

These density signals pass to the highlight monitoring circuit (to set the peak highlight level), the black signal extractor and the colour correction masking circuits. The black signal extractor corrects the black components of the mask signal. It is also used for making the "black printer" separation after that signal has passed through a curve correction amplifier.

After colour correction the signals pass to the shadow density control. This variable gain amplifier adjusts the deepest shadow, so that at least one separation will print solid ink. The press correction curve compensates for gradation errors in the screening and printing process. Like the "black printer" gradation curve correction, an amplifier with a non-linear transfer function provides the press correction: the characteristics of subsequent printing processes determine the shape of this curve.

After leaving the gradation curve correction amplifier, the signals accurately represent corrected colour separations and are then referred to as the cyan, magenta, yellow and black printer signals. They pass sequentially to a range setting amplifier, which introduces further compression. Up to this point the signals have represented a density range of 0 to 2.0. As the subsequent transmission and printing processes can handle only a density range of 1.7 (equivalent to 34dB contrast ratio), the signal is compressed (not crushed as previously) to 1.7 before passing to an anti-logger, which converts the signal back to its transmittance form. Finally, the transmitter signal passes to a matching amplifier which adjusts the signal levels to match the modulator in the facsimile transmitter.

Loggers and curve correction amplifiers

The circuits used for logging and curve correction employ concave and convex transfer functions or combinations of the two. Figs. 6 and 7 show the basic circuits. For simplicity, the circuits depicted use only two feedback diodes, whereas practical circuits employ more diodes to increase the accuracy of the approximation.

Fig. 6 shows that with small input signals the amplifier functions as a conventional operational amplifier, with gain $G_1 = R_f/R_0$. However, as the signal level increases diode D_1 starts to conduct, so that R_1 is shunting the input resistor and increasing the gain to G_2. With even greater signals D_2 conducts to shunt the input resistor with R_2 as well and R_1, thereby increasing the gain further to G_3.

Fig. 7 shows the convex transfer functions. As in the concave circuit, the opera-

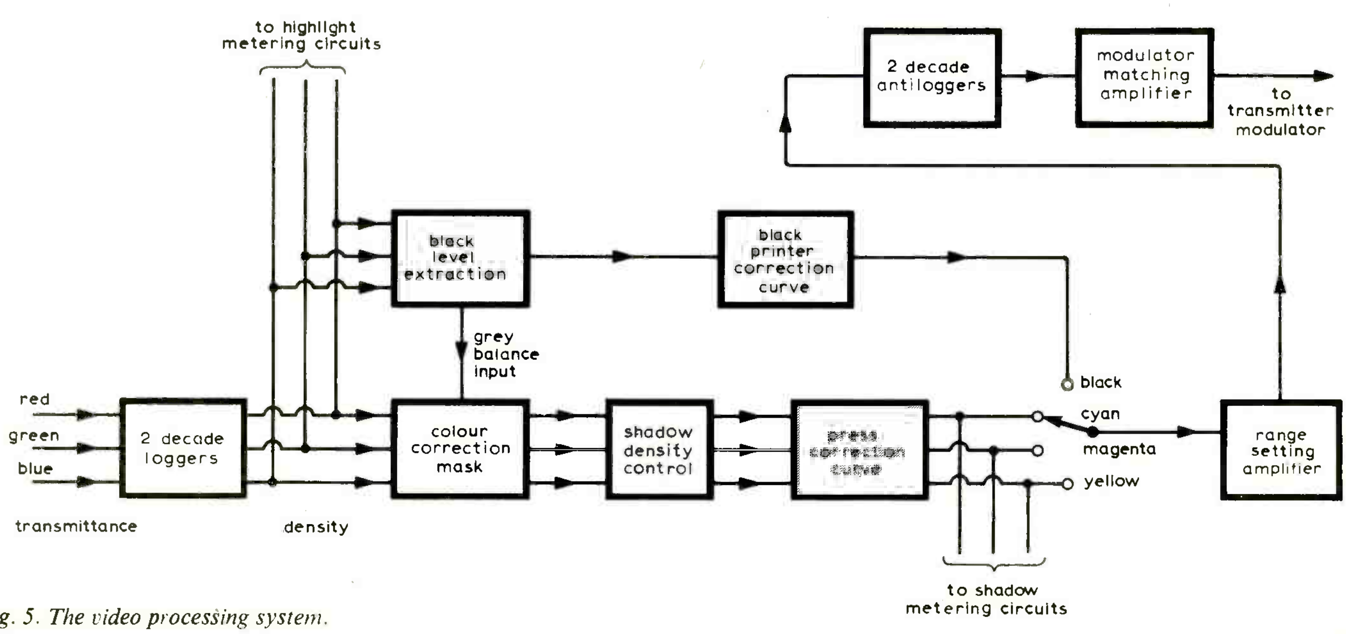


Fig. 5. The video processing system.

tional amplifier functions as a normal linear amplifier until the signal level rises above the break point. Notice that the break point in this case occurs when the *output* rises above a certain level as opposed to the input on the previous circuit. Above the break point D_1 conducts, shunting R_f by R_1 so that the gain *decreases*.

In practice logger circuit design requires considerable attention to detail. The circuits can operate between zero and positive levels or between zero and negative levels, depending upon the choice of suitable diodes and biasing. The need to use preferred value resistors causes further complications because this leads one to modify break points and slopes to get the best approximation to the curve consistent with practical resistor values.

Colour correction

The colour masking equations used to compensate for the deficiencies in the colour of inks are well known and are derived from density measurements taken through red, green and blue filters. Thus, if one measures a sample of magenta ink through the three filters, one obtains three density readings. Two of these readings will be low because magenta ink is supposed to reflect red and blue light, stopping green, while the green filter will give a high density reading. One takes a complete set of readings, so that each ink is measured through each filter (see Table 2).

Table 2: ink density readings

	cyan ink	magenta ink	yellow ink
red filter	C_R	M_R	Y_R
green filter	C_G	M_G	Y_G
blue filter	C_B	M_B	Y_B

Dividing these readings by the principal density readings C_R, M_G and Y_B yields the coefficients of a matrix representing the colour correction equations.

$$\begin{pmatrix} D_r \\ D_g \\ D_b \end{pmatrix} = \begin{pmatrix} C_R/C_R + M_R/M_G + V_R/V_B \\ C_G/C_R + M_G/M_G + V_G/V_B \\ C_b/C_R + M_b/M_G + V_B/Y_B \end{pmatrix} \begin{pmatrix} C \\ M \\ V \end{pmatrix}$$

i.e. $Y = AX$

The solution to this matrix is

$$X = A^{-1}Y$$

where A^{-1} is an inversion matrix. We chose to use the matrix form in preference to a simultaneous equation because of the relative ease with which one can solve matrices using computer time sharing services: the computer has a sub-routine which inverts the matrix from the simple instruction

$$MAT\ R = INV(Q)$$

With a little further programming the computer will dutifully print out that

cyan = 100% red — 15% green — 1.5% blue
magenta = 110% green — 39% red — 6.8% blue
yellow = 100% blue — 10% red — 60% green

This particular solution applies to a specific set of density readings taken from a commonly used set of printing inks.

Thus if one inputs to the computer density readings for the printing inks used in the reproduction process, the computer will print out the required cyan, magenta and yellow mask percentages, which form the basis of the correction circuit design.

We could use the programme further to design the whole circuit, but unlike the non-linear amplifiers, several of which we had to design, we designed the overall circuit once only. Here, the computer's strength lies in its ability to solve a difficult equation very quickly. The computer programme is also useful for comparing different inks: the

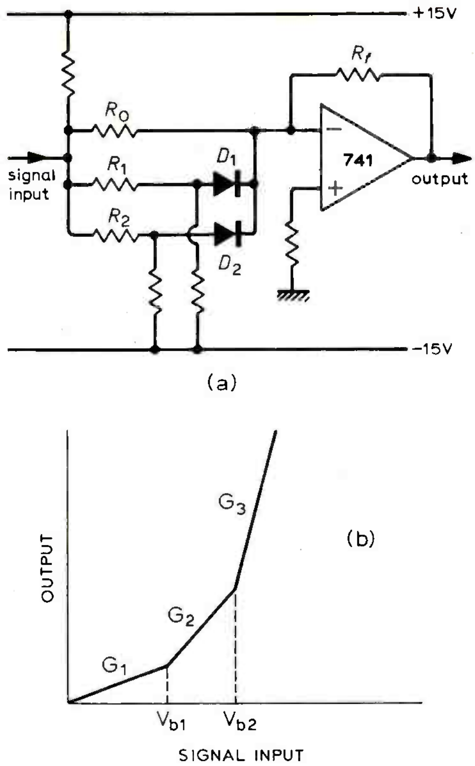


Fig. 6. (a) Circuit for producing a concave transfer function; (b) output/input characteristic of the circuit.

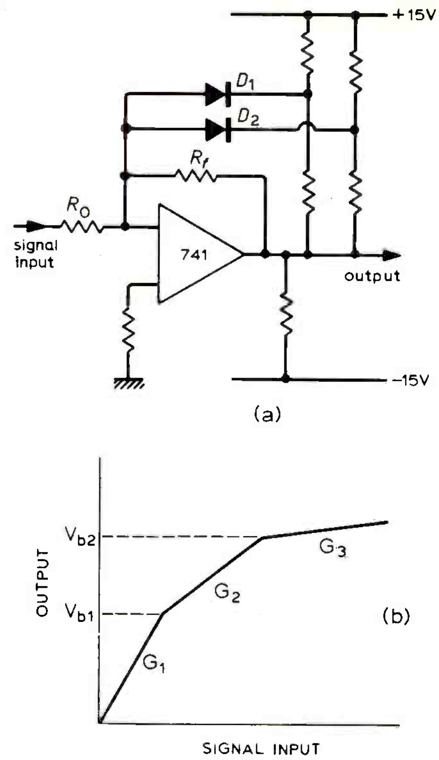
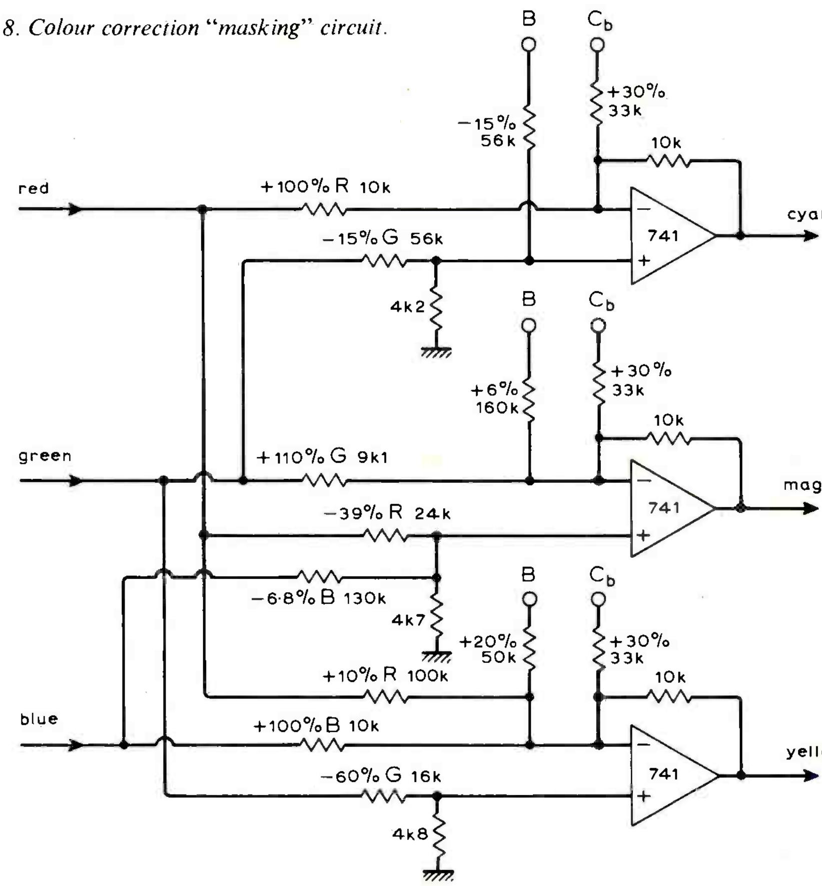


Fig. 7. (a) Circuit for producing a convex transfer function; (b) output/input characteristic of the circuit.

Fig. 8. Colour correction "masking" circuit.



solutions to the equations shows quite clearly if the differences will have a significant effect on the masking amplifier design.

Fig. 8 depicts the circuit of the masking amplifier. The red, green and blue signals enter directly into the summing input of an operational amplifier, while correction signals pass to the non-inverting input of the operational amplifier to subtract from the main signal fed to the summing input.

If a monochrome signal enters a masking amplifier all three inputs will be identical. Adding or subtracting black signals from the black signal extraction amplifier makes the three outputs identical; thus in the cyan channel we have

$$+100\%\ R-15\%\ G-15\%\ B+30\%\ C_B$$

where C_B is a clipped black signal. For a monochrome picture this becomes

$$+100\%\ B-15\%\ B-15\%\ B+30\%\ B = 100\%$$

Similarly the percentages for the two other channels add up to 100 per cent. The clipped black (C_B) signal ensures that when all three colours are present, together with black, the amount of coloured ink printed is reduced. This technique of printing less coloured ink in very dark areas is called "under colour removal".

In practice, the cyan, magenta and yellow channels are not balanced to 100 per cent because an equal weight of ink does not give a very pure black. The actual weights required depend upon the type of ink used, but 100 per cent cyan, 90 per cent magenta and 85 per cent yellow are typical percentage ink weights for acceptable grey scale reproduction.

The three output signals from the colour mask pass to the shadow density control (Fig. 5), whose function is to be able to adjust to accommodate a wide range of original transparencies. The control comprises a three-channel switched-gain amplifier, which sets the shadow reading on the shadow meter. The system ensures that solid ink is always printed somewhere within a picture: this approach avoids producing flat desaturated prints even when the original transparencies have been poorly exposed.

The press correction curve is a non-linear amplifier, which compensates for the distortions which subsequent screening and printing processes introduce. The signals from this stage pass through a channel selector switch to the transmission circuits.

Black printer channel

In this colour system black is defined as the colour generated by equal signals from the red, green and blue channels, the three photomultipliers being set to give equal signal outputs from a monochrome transparency. The black signal extractor gives an output whenever all three channels represent equal quantities of ink, that is, a signal equal to the lowest input. The black signal output can be either clipped or unclipped, and in either form the signals can be used to correct the grey scale response of the colour correction circuits.

Transmission circuits

Although the cyan, magenta, yellow and black signals are all available simultaneously, the IPC system transmits them sequentially. This mode of operation enables any newspaper office with a conventional telephoto receiver to receive the transmissions and reproduce colour. The four signals are switched one at a time to the range setting amplifier (Fig. 5), which linearly compresses the signals to allow for the limited range of subsequent processes. The screens the newspapers use determine the lower limit, while the modulation depth and detector circuits of the telephoto transmitter/receiver system fix the upper limit. In practice the lower limit is a density range in excess of 1.4 and an upper limit of 34dB, which is equivalent to a density range of 1.7. The range may be set anywhere between these two values, so we chose to use the optimum value of 1.55.

The compressed signal finally passes to an antilogging circuit, which converts density back to transmittance. The modulator matching amplifier ensures that the outgoing signal corresponds to −7dB for the highlight and −36dB for the shadow. (The transmitter can modulate down to −41dB.)

Test results

After the production prototype of this machine (see photograph) had yielded very satisfactory results in the laboratory, we installed it in the United Press International office at the Olympic Games Press Centre at Munich in 1972. Countries as far apart as France, Sweden, South Africa and Japan received separations daily of colour photographs of sporting events of interest to the particular countries.

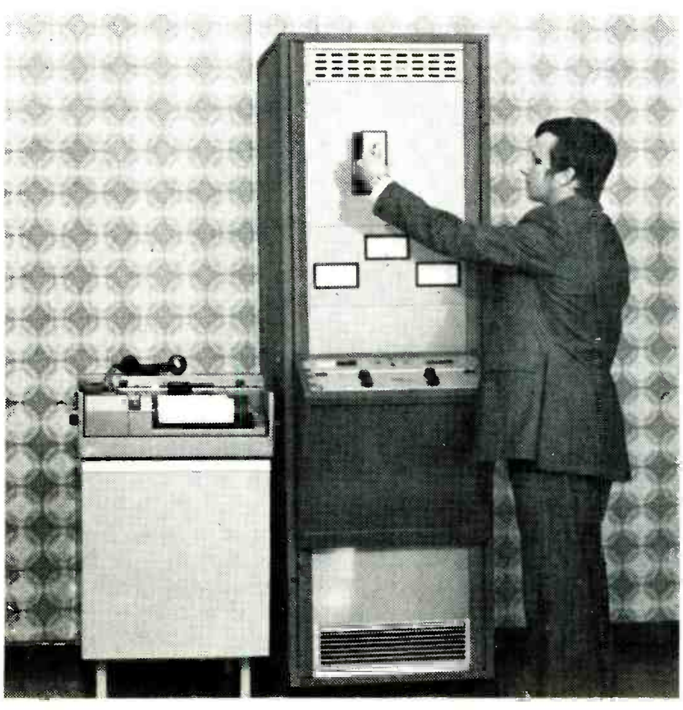
The front cover of this issue of *Wireless World* shows a set of separations transmitted during the Olympic Games, when Mark Spitz had won five of his seven gold medals. For the purposes of the cover illustration the separations are shown reduced in size and in the actual colour components, cyan, magenta, yellow and black, used for printing a colour picture. As received on a telephoto receiver the separations are 10in × 11in and, of course, in monochrome (black and white).

Future developments

Following the technical success of the transmissions from Munich we are now considering a number of possible developments of this system. For instance, we could develop a high speed model capable of transmitting on 48kHz lines. Also, if we used the 48kHz network, we could transmit all four separations simultaneously to four separate receivers. As the present system uses a bandwidth of only 500Hz there is sufficient capacity on the normal 3.5kHz telephone circuits for simultaneous transmission of the three colours if we used single sideband transmissions.

As the present model is very large and must be stationary, its use is restricted to events such as the Olympic Games. We could develop a simple portable scanner, which could relay the signals through the large machine. To ensure that the portable unit was as simple as possible, we could arrange for the large machine to carry out all the colour corrections.

However, very few newspapers are currently capable of printing news pictures in colour. Many papers incorporate preprinted colour advertising and colour studio pictures, but they do not have a full-colour printing capability and so cannot use separations received through colour telephoto. Therefore, future developments will depend upon the newspaper industry making wider use of colour.



Complete prototype colour telephoto transmitter.

Acknowledgements. The author thanks D. Haley and P. Busby, who designed the equipment used in Munich, J. V. Ashworth, for originally suggesting this work, and the head of IPC Technical and Information Services for permission to publish this article.

Reference

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New Audio Products

A selection of products introduced at Sonex time

Audio exhibitions in hotels serve at least two fundamental needs — an opportunity to hear equipment in rooms that approximate domestic surroundings — in terms of size at least — and an opportunity to communicate with people in the business. Sonex 73 was successful on these counts. But the fact that the venue is generally not in the public interest in terms of cost and convenience lends weight to the argument we heard from a number of exhibitors, that the trade viewing days should be extended, at the expense of public days. As such an exhibition seems an ideal place for professional engineers to exchange information, we'd like to see this further promoted by a more formal presentation of recent research and development in audio and acoustics. This should take the form of a conference running parallel with the show and taking the place of the poorly attended panel discussions which were organized at this year's exhibition.

Amplifiers and tuners present relatively little difficulty in assessing what they can or can't do in terms of their performance. Even though ambiguities do exist in specifications — especially with the rated power output of an amplifier — an informed perusal of standardized specifications can yield an accurate guide to the capabilities of an amplifier or tuner circuit. This is not the case, however, with loudspeakers. Amplitude-frequency response and impedance curves give an indication of the performance when the speaker is fed with continuous signals (e.g. sine waves) but this is not representative of the performance under real or transient signal conditions. This suggests that additional information is necessary and indeed research being done by KEF Electronics indicates the importance of the phase-frequency response and the "decaying" frequency response obtained by a Fourier analysis of different time intervals of an input transient (unit impulse) signal. The significance of this information was tentatively realized by Harwood of the B.B.C. during the 1950s, but it is only recently that instrumentation providing digital analysis of transformed signals has become available and made speedy and accurate measurements possible.

In the light of this missing information and in coping with the poor acoustic environment in the hotel demonstration rooms for listening to reproduced music, it is impossible to select the "best" new speakers which appeared at the show. The following is however a cross-section of some of the more interesting designs which appeared.

The Jordan Watts Jupiter TLS is a transmission-line enclosure with two of the Jordan Watts full range modules used as drivers. Energy from the rear of the units is fed down and dissipated in a long folded tunnel which is lined with acoustically absorbent material. In this case different types of energy absorbents are critically positioned so that the restriction to speaker movement is minimized. The aim of this is to improve the efficiency of the system, inherently low with the transmission line. The main specifications are stated to be frequency response 35Hz to 22kHz ± 4dB, distortion $<1\%$ at 60Hz and $<0.3\%$ elsewhere, sensitivity is 10W pink noise for 95dB s.p.l. at 1m, nominal impedance is 8Ω and the speaker is recommended for use with amplifiers having power outputs from 20 to 50W continuous. Price of the Jupiter TLS is £86 each.

An extension to the transmission line principle is employed in the relatively new IMF ALS40 loudspeaker which is an "active line" system. The usual passive part of the transmission line is complemented by an active radiator driven via a suitable crossover network. The result is an extension in bass response and/or increased efficiency around the existing l.f. bandpass, while at other frequencies where a transition is occurring into non radiation from the "port" the system can be regarded as an acoustic dipole. A secondary advantage of the active line system is that below its operating range, the phase relationships are such that the low frequency drivers are acoustically coupled against diaphragm motion, thus acting as a high-pass filter to unwanted sub-sonic signals. The ALS40 measures approximately $13\frac{1}{2} \times 13\frac{1}{2} \times 26\frac{1}{2}$in, bass unit is an 8in foam surround, sub-bass driver is an 8in roll surround, mid-range unit 5in impregnated cone contained in a separate line, domed tweeter, efficiency measured via 40W pink noise 1m on axis produces 100dB s.p.l., nominal impedance is 8Ω.

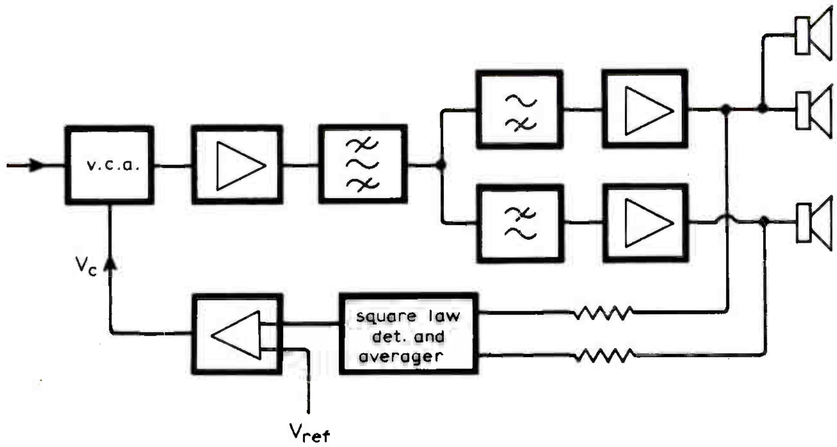
Other speakers of interest were the Spendor BCIII: 12in l.f. unit, 8in mid-range both with plastic cones, crossover points at 700Hz, 3 and 13kHz, nominal impedance 8Ω, power rating 70W peak programme — the Kmal Elf Major which is a damped reflex system incorporating an internal acoustic filter chamber. The drive units are 8in rolled surround bass, 5in mid range and 3in tweeter, nominal impedance is 8Ω and power handling capacity is 22W continuous. All the drivers in this system are standard units from Elac and EMI which have been specially "doctored" to meet the design requirements.

A new name at Sonex was Gale Electronics who introduced the GS401 infinite baffle system. The speaker is priced at £81 plus v.a.t. although production does not start until about the end of August. Nominal impedance is 4Ω. Two 20cm bass drivers are employed and are complemented by a 10cm mid-range unit and a 19mm dome tweeter. Fundamental resonance of the system is 50Hz.

Another new loudspeaker is the soft dome speaker, SX-3, from JVC, which features improved directivity at h.f. i.e. with half-power points at $\pm 60°$, at least, at 4kHz. This is due, JVC say, to the soft dome vibrating in a radial way as opposed to the piston-like action of a hard dome. As well, the speaker frames are mounted outside the front panel with punched metal covers giving the unit a distinctive "functional" appearance.

Amplifier and tuner design seems to have reached a pinnacle in performance capabilities — at least for the time being. Circuit innovations are now few with new models being additions to established ranges of equipment rather than being "innovatory". The use of integrated circuits is becoming more widespread although i.cs are still very limited in their application to high performance audio circuits — limited that is in their power handling capabilities and noise performance for pre-amplifiers. The IMF Galactron IC10 (£298 + v.a.t.) is however a high quality amplifier which has a pre-amp using i.cs. Power output into 8Ω with both channels driven and switched to mono mode is 75W ± 0.5dB. Under the same driving conditions, distortion is less than 0.2% from 70W-0.1W (20Hz-20kHz). Damping factor with an 8Ω load is greater than 80 and hum and noise of the power amplifier below 80W into 8Ω is better than 90dB. Incidentally, the leaflet describing the Galactron states that the circuits contain 24 transistors, 34 diodes and "four to eight integrated circuits". Pardon?

The Metrosound ST40 is a new amplifier whose power output circuitry has been redesigned. Although we have no details of the circuitry at the time of going to press, a typical distortion figure of 0.05% indicates that an improvement has been made. Power output is 20W continuous per channel into 8Ω. Hum and noise are -65dB on magnetic phono input. J. E. Sugden has a range of power amplifiers, control units, integrated amplifiers and tuners. Basic improvements have recently been made to the power amplifiers but this amounts to improvement in power ratings by an increase in voltage rail value — and corresponding output devices and bias



Voice-coil protection circuit in KEF speaker, model 5/1AC, uses voltage-controlled attenuator that is actuated when the mean power over 5 seconds reaches an unsafe level, as set by V_{ref}.

arrangements. Noise performance has also been improved. The range includes the P51 power amplifier (45W continuous into 8Ω per channel £80.00), C51 control unit (£50.00) and the A48 integrated amplifier (40W continuous per channel £95.00).

A new model introduced at Sonex to the Goldring range of turntables was the GL78. It is a further development of the GL75, utilizing the same drive mechanism with variable speed adjustment between 30 and 86 r.p.m. Changes which have been made are the introduction of a new lighter headshell — the arm has adjustable stylus pressure from 0.5 to 5gm — and a restyling of the lift/lower lever for easier operation. Price is now £69.90 + v.a.t. and this includes the plinth and cover.

The latest deck from Philips, the GA407, is sold with the Philips GP400 "magneto dynamic" cartridge. It is a two-speed deck using a low-speed, synchronous motor and belt drive with a free-floating sub-chassis for turntable and arm to minimize wow and rumble. Two features not previously seen on Philips decks are automatic arm return to rest position and a stylus force meter which gives a direct reading.

A new name in audio amplifiers is EMI who introduced a 15-watt per channel amplifier together with a decoder for SQ records. The amplifier, type 1515, gives an harmonic distortion of 0.2% at full output (1kHz, single channel), but is not quoted at lower levels, and costs £54.

The EMI SQ1500 decoder has six-pole phase difference circuits with a phase difference of 90 ±10° over the band 20Hz to 18kHz. The decoder, fitted with a fixed blend option and an "ambience" matrix switch for four-speaker playback of ordinary stereo records, uses a p.c. board announced at about the same time by the relatively new company of Tate Audio Transmission Equipment. They make a range of decoders based on two circuits, the single i.c. circuit, presumably similar to the circuit on page 116, March issue, with its 90 ±10° phase difference over 100Hz to 10kHz. The wider band six-pole circuit has a typical distortion of 0.04% (0.08% at clipping) as opposed to 0.1% (1% at clipping) for the i.c. version. The i.c. version is available in four forms; ready-built on a p.c. board for £8.95, with power supply, switches and volume control for £16.95; with cabinet kit for £24.95 and fully built for £28.95. The "high-definition" type is also available in these four versions, priced from £12.95 to £34.

Other recently announced SQ licensees are Thorn Consumer Electronics and Rogers Developments (making a total of 60 brand names now using SQ circuitry). The last-mentioned having showed their SQD1 model at Sonex, incorporating the single-chip circuit power supply and 10-40 blend resistors for £15.

Sansui took the opportunity of Sonex to announce a licensing arrangement for the QS regular matrix and their Variomatrix technique of enhancing channel separation. Up until now only Sansui has been making QS equipment. The Variomatrix circuit is used now in the latest consumer decoder for four-speaker playback of stereo records in place of the phase modulator circuit previously used. The complete p.c. board for the QS Variomatrix circuit costs around £3 to manufacturers. It was interesting to see that Sansui have incorporated a "phase matrix" position on their equipment, which it is claimed decodes SQ records using two phase shift circuits, after sum and difference matrixing, instead of four.

There are now 19 recording companies using Sansui equipment, offering over 400 QS records under 24 labels, the latest to go Sansui being a French affiliate of Decca. There were 170 CD-4 records and 240SQ records at the start of 1973, with no doubt many more CD-4 to come now that WEA (Warner-Electra-Atlantic) is adopting the discrete system.

The quadraphonic equipment of Marantz, shown for the first time in the U.K., uses a Vari-matrix technique for playback of coded and uncoded records through four speakers. No doubt this will be similar to the National "acoustic field dimension" with variable blending, but it's not clear what the phase difference is between the rear speakers. On all five models (amplifiers and receivers) provision is also made for adding SQ decoders (type SQA-1 with front-to-back "logic", type SQA-2 with full logic) or any other decoder that may become appropriate in the eyes of Marantz.

As well as selling SQ decoders, EMI Sound & Vision Equipment also sell speakers specially built for surround-sound playback of stereo materials from a two-channel amplifier. Called LE3SS, they have double-wound voice coils in the drive units in an impedance ratio of 11:5. The voice coils of four speakers are connected in such a way that the signals $11L + 5R$ and $11R + 5L$ are fed to the front pair and $11L - 5R$ and $11R - 5L$ to the rear pair. The two voice coils can of course be connected in series giving a 16-ohm impedance.

A new top-quality pickup cartridge is introduced by Shure. Called the V15III, it supersedes the V15II "Improved" and has improved amplitude-frequency response to the extent that the 2 or 3dB droop in response at around 10kHz with the V15II is completely removed. Laminating the magnetic core material and moving the h.f. resonance out from 20 to 23kHz has meant that the new cartridges have an average deviation of only $\pm\frac{1}{2}$dB up to 20kHz, though individual pickups can vary up to ±3dB at 20kHz. Shure will not guarantee performance for CD-4 discs, but the new pickup is clearly much better suited than its predecessor, being 12dB down at 30kHz as opposed to 22dB. The new pickup also features better trackability with lower consequent distortion.

Ortofon announce a new moving-coil cartridge with reduced equivalent stylus tip mass and light-weight cantilever to give a typical response that extends ±3dB up to 50kHz. Data for this SL15Q is similar to that of the SL15 MkII, except for the stylus which is a Shibata type.

Extras

- The H10 and H20 dynamic headphones designed by Sonab of Sweden have respective frequency ranges of 20-14000Hz (±3dB) and (±2dB). Harmonic distortion at 120dB s.p.l., and 1,000Hz is less than 1% for the H10 and less than 0.3% for the H20. This sound pressure level is the approximate threshold of pain so normal listening levels would not approach this.

- Five sound selector units are now produced by Tape Recorder Spares Ltd. Four units select either headphones or up to three pairs of loudspeakers. A fifth unit, HZ793, provides the facility to connect any of three signal sources to any three amplifiers.

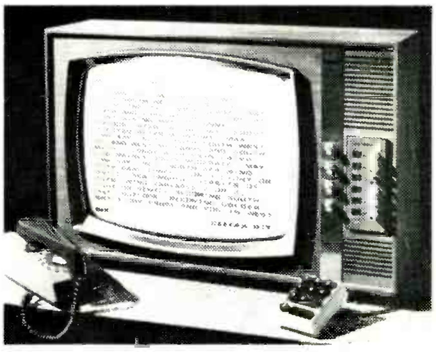
- A completely new range of amplifiers, tuners and receivers is launched by Armstrong. The new Series 600 which is visually very attractive, comprises the stereo amplifier with 40 watts of continuous sine wave power per channel (both channels driven) combined with very low distortion (0.08% at 1kHz all power levels), with electronic switching in the preamplifier eliminating switch clicks (£76). An f.m. tuner has a sensitivity of 1 V (30dB s/n), distortion of less than 0.2%, a 38-kHz rejection of 50dB, and a capture ratio of 1.75dB.

TV Information Service

Signal format for B.B.C. system

The B.B.C. has decided a signal format (see diagram) for Ceefax, its proposed television broadcasting information service announced last year, and field trials of the system will be started this summer. Ceefax will enable television receivers to display on demand information such as weather reports, motoring and other travel news, sports results, stock market prices, etc., in fact anything which can be shown by the written word. The information — rows of alpha-numeric characters — will be transmitted by a binary digital code within the normal television signal, and the received data will be processed by a separate unit connected to the television set. In this unit the data will be stored as different "pages" of information which can be up-dated as additional signals are received. A selector will enable the viewer to choose any of 32 stored "pages" for display on the receiver screen at any time he wishes.

Data signals corresponding to the 32 "pages" of information, will be inserted on lines in the television field-blanking period for transmission. The receiver unit will contain data-extracting and decoding circuits as well as data-storage and character-generation circuits which will enable the pages of information to be stored and displayed in alpha-numeric form on the receiver's picture tube. Storage will be necessary at the receiver because the rate of transmission of message data in the system is relatively low (11.2 kbits/sec), requiring about 15 seconds to transmit 32 "pages". The



Receiver displaying a "page" of information, with the page selector unit on the right.

television display, on the other hand, requires a new television field (or "page") every 1/50th of a second, and storage will be used to accumulate the received data so that it may be read out repeatedly to "refresh" the television display. The data rate is, of course, more than adequate for the transmission of the intelligence itself.

The minimum required storage capacity in the receiver is thus one page of information; this demands a data storage capacity of 5376 bits.

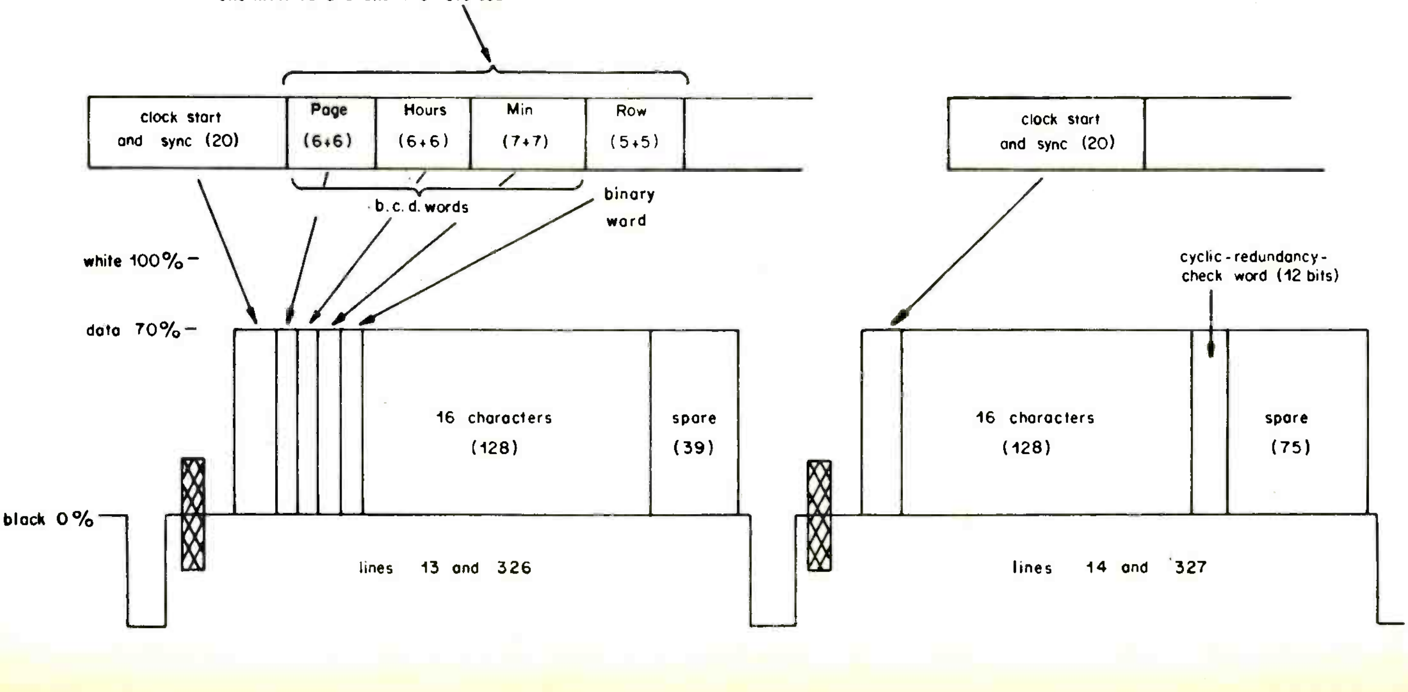
A Ceefax page comprises 24 horizontal rows of characters, each row containing 32 characters and spaces. Twenty picture lines are allowed for each row including the space between rows.

A new character row will be transmitted every television field, which means that the 32 "pages" will require 15.36 seconds for transmission. The rows of different pages will be transmitted in an interleaved sequence and, whenever a viewer selects a page, data will begin to be "written" into the store of his receiver and he will see the page begin to form, row-by-row, until it is completed after 15.36 seconds.

The signal transmission during each television field-blanking period will use the adjacent television lines numbered 13 and 14 on even fields and the adjacent lines 326 and 327 on odd fields. The signal consists of the characters in coded form, together with coded "addressing", protection and synchronizing data pulses.

Each character is transmitted as a 7-bit code word plus one parity bit for protection, making 8 bits per character. Non-return-to-zero coding is employed, using "raised-cosine" pulses with approximately 4.5MHz bandwidth. Each television line has a capacity of 235 bits of data and it will be seen from the diagram that the two lines carry between them 32 characters, comprising the transmission of data for one complete character row every television field.

The "clock start" and "address" blocks are also shown, together with blocks for clock-time information to be inserted in slowly changing information "pages".



Signal format for Ceefax. Address words are shown top left. Data pulse at 70% level corresponds to "1"; at 0% level to "0". Figures in brackets are numbers of bits.

News of the Month

P.C.M. for Post Office trunks

As a first step in developing a digital information trunk network, and preparing for new facilities, the Post Office has placed contracts with STC, GEC and Plessey to develop pulse code modulation digital transmission systems. At present the telecommunication "highways" between centres of population carry thousands of messages — telephone conversations, TV and radio signals, and computer data — as signals in analogue form. They are kept separate by sending them at different frequencies — the technique known as frequency-division multiplexing (f.d.m.). With p.c.m., as is well known, the messages are converted to digital signals and messages transmitted over the same bearer circuit are kept separate by time-division multiplexing — slotting the pulses from one source into the intervals between the pulses of others.

Digital systems can provide the same quality of performance as the present analogue systems and may in future do this at greatly reduced cost. They allow much simpler signalling systems to be used for routeing calls through the network, simplify the multiplexing of different signals and, for complicated signals for TV and viewphone for example, permit greater exploitation of the transmission medium. In addition they pave the way for the introduction of cheaper, quicker, switching systems using methods operating directly on the digital information under stored programme control.

The decision to develop a digital system for the U.K. trunk network stems from the results of feasibility studies carried out for the Post Office by GEC and Plessey in 1970-71. These studies confirmed that it is technically possible to introduce a digital system using the standard 1.2/4.4mm coaxial cable pairs now in use for multichannel f.d.m. transmissions.

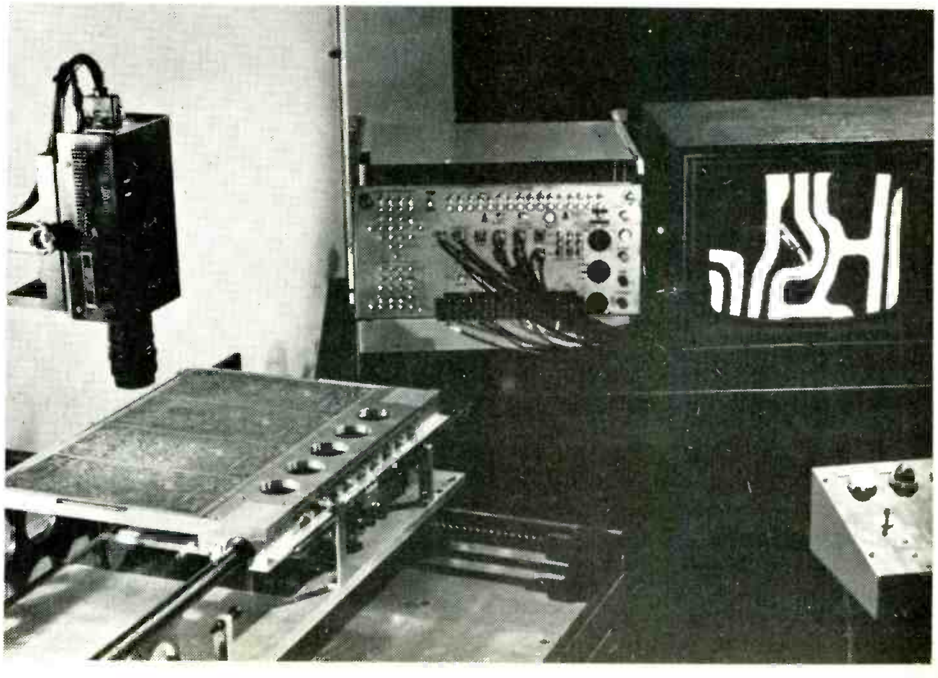
Under development contracts, STC, GEC and Plessey will design, develop, manufacture and install systems transmitting information at a rate of 120M bit/s and compatible with the Post Office's existing 12MHz analogue system for 1.2/4.4mm cables, using the same repeater spacing, housing and power feed arrangements. For this purpose, the Post Office has set aside spare coaxial pairs in its trunk cables between Guildford, Portsmouth and Southampton. Each system will be capable of transmitting up to 1,680 telephone conversations simultaneously by p.c.m./t.d.m. They should be ready for Post Office evaluation early in 1975. The European Committee for Post and Telegraphs has been discussing standards for p.c.m. for a number of years and recently decided that 30-channel systems should be one of the recommended standards. The British Post Office is now adopting this recommendation.

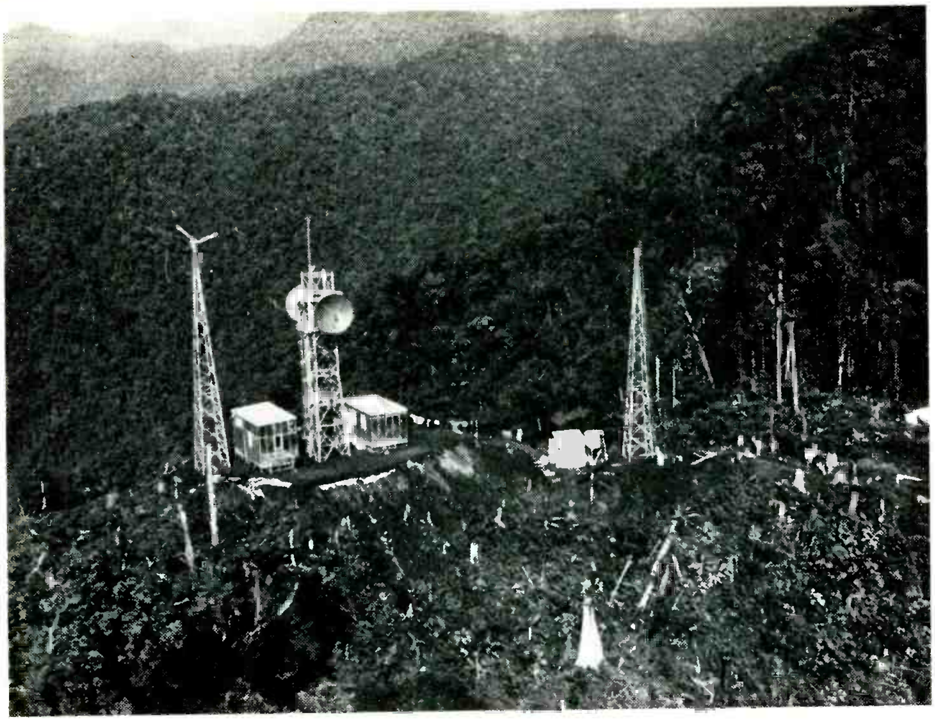
Defect inspection device

The Central Research Laboratory of Hitachi, Japan, has developed a recognition device, the "HIVIP, Mk 5", that automatically detects, through optical pattern recognition, defects in complicated patterns such as i.c., l.s.i. and printed circuit boards. Development of this device makes possible an unmanned optical inspection process and, as a result, a big improvement in the reliability of products. The device is made up of a TV camera, a defect recognition device, and a colour display unit, which indicates the result of the recognition (see photo). When the object to be inspected is placed within view of the TV camera lens, the camera picks up the image and sends it to the defect recognition device which checks the image signal and determines whether there is any defect or not, examines its size and automatically rejects the defective product.

The defect recognition device can also pick out only the defective part from the image and show it on the display unit. One method of automating this process was devised by comparison with a normal pattern (dictionary) that had already been memorized. However, this method requires massive information storage, and positioning problems of input pattern arise in setting it to the normal pattern. Therefore operational costs and difficulties increase. On the other hand, the Hitachi defect inspection device does not memorize the normal pattern but uses a reference-free method of defect recognition. A defect-free normal pattern is generated by real-time mode from the input pattern itself picked up by the TV camera, and defects are detected automatically from the difference between input and generated standard patterns. There is no need for a large memory unit or positioning process, and a special purpose processor that operates on real time (1/60 sec. per image) has been produced as the defect recognition device. With this device, it is possible to automate the old visual inspection method and completely eliminate errors. Also, since there is no process for memorizing a normal pattern, the device starts operating immediately, even with a new pattern.

Automatic defect inspection system developed by Hitachi. The device automatically detects, by optical recognition, defects in complicated patterns. The defective part is displayed on a TV screen.





Receiving and transmitting aerials of telecommunications equipment designed by Page Communications Engineers which links the copper mining operations on the island of Bougainville with the mainland of New Guinea.

Telephone telemetry

A transmitter and receiver developed by Danica Elektronik of Denmark enable e.c.g. and other physiological and physical data to be transmitted along ordinary telephone lines or by radiotelephones, such as may be used in ambulances.

The two small instruments, mains or battery powered, make up an f.m. carrier system with a carrier frequency of 1700Hz and a frequency deviation of $\pm 15\%$. They are directly coupled to the telephone line to reduce noise. When connected, a switch on the front panel selects between normal telephone operation and carrier transmission.

The input e.c.g. amplifier in the transmitter is a balanced high input impedance amplifier with a high common-mode rejection ratio. The amplifier output modulates the frequency of an oscillator, which acts as a carrier fed to the telephone line via a line amplifier and an output transformer. In the receiver the signal from the balanced input amplifier is band-pass filtered, before it is fed to the f.m. discriminator, to reduce noise. The demodulated signal is fed to an oscilloscope, which has provision for direct read-out of the patient's pulse rate, and to the recorder output socket. The timebase is calibrated for pulse rate read-out at 25mm per second.

Stereophony pilot tone

With the increasing number of stereophonic programmes, the B.B.C. has been considering its policy in relation to the transmission of the pilot tone which is part of the stereo signal. Stereophonic receivers are usually designed so that when the pilot tone is present they switch automatically to the stereo mode and indicate that this has taken place.

Certain programmes, particularly those made up of recorded items, contain both stereophonic and monophonic contributions, and with these cases it is not practical to switch the pilot tone on or off between individual items. On the other hand, it is not desirable to transmit the pilot tone when purely monophonic programmes are being transmitted.

The B.B.C. has therefore decided on the following policy: During stereo programmes (or programmes containing stereo items) the pilot tone will be transmitted. Such programmes will normally be shown as "stereo" in the *Radio Times*. During wholly monophonic programmes of substantial duration the pilot tone will be switched off.

This practice will be applied to Radios 2, 3 and 4, as well as to Radio 1 when that programme is transmitted on v.h.f. It will not be possible, however, to apply it immediately to the Radio 3 transmitters serving the Midlands and the North.

Aircraft tactical simulator

An advanced flight simulator is being "flown" by trainee and experienced Nimrod crews after hand-over of the equipment by the manufacturers, Marconi Space and Defence Systems. Built as the first of a number to be supplied to RAF Strike Command, the simulator will reproduce for twelve trainee crewmen all operational facets of the Nimrod, which is an anti-submarine and maritime reconnaissance aircraft.

The system is used to simulate comprehensive anti-submarine exercises, with all ship, submarine and aircraft inputs, at a fraction of the cost of the real thing and in secrecy. All operational equipment, including the radar, sonar, electronic counter-measures, tactical navigation and weapon delivery systems, is fitted in a replica Nimrod, to reproduce actual missions, even down to engine noise and low-level buffeting. The same exercise can be repeated indefinitely to fix in the minds of the crew the procedures necessary for what is acknowledged to be a most difficult form of defence.

Aid in spinal therapy

A miniature version of a Swedish-developed force transducer normally used for heavy industrial measurements has been successfully applied to the treatment of lateral curvature of the spine. A tiny version of the ASEA "Pressductor" sensor was implanted in a stainless steel distraction rod used in the surgical treatment of 12 patients with idiopathic scoliosis — abnormal spine curvature — at Gothenburg University Hospital, Sweden.

The patients, none of whom reacted unfavourably to the rod's presence, carried out isometric training during the post-operative period. The system allowed the axial load on the distraction rod to be measured during these exercises.

Police computer aid

Glasgow City Police have on order what is claimed to be the biggest and most advanced computerized information system in Europe. Based on an Argus 500 Computer, it is designed to aid the police in their work in the Glasgow area. As well as providing a control room, it will have a message routeing system and a patrol and traffic car location and status service. The system will be suitable for extension when the Glasgow City Police become part of the Strathclyde Regional Police in 1975. At this stage the Glasgow project is experimental. When it is proved it will be handed over by the Home Office as an operational system.

In the control room each operator will have two visual displays. One will show the resources available to deal with an emergency, and the other, using a display with optical rear projection, will show the location and status of available forces superimposed on a map of the area. This display will be kept up to date by reports from a small push-button control box in each patrol vehicle. An automatic teleprinter message routeing facility will replace the manual procedures of the old teleprinter network. The facility is capable of covering the whole of the Strathclyde police area.

The police computer will provide information to a local authority computer. This information can then be used for statistical surveys and management and resources planning. For immediate access to criminal records, the computer is capable of being interfaced to a police national computer at Hendon.

Drawing by computer

An experimental computer system controlled by a paper "keyboard" has been developed by IBM at Yorktown Heights, New York, to convert freehand sketches into fully proportioned drawings. Placed at random on an "electronic tablet", a sketch and the paper keyboard are simply touched with an electronic pen to enter graphic or alphanumeric data for processing by the computer.

The experimental system is designed to speed the creation, filing and updating of large volumes of graphic material such as maps and engineering drawings. A rough drawing, no matter how much out of scale, can be automatically turned into a finished product a few moments after the assignment of proper dimensions. The paper keyboard, through which the automated computer functions are controlled, can be shifted from one place on the "tablet" to another to suit the user's working needs.

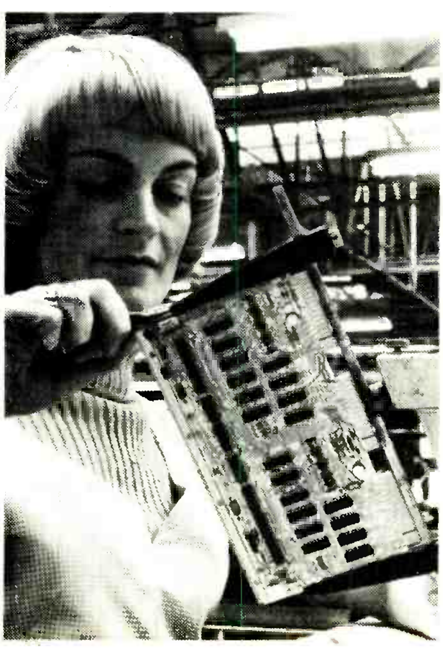
European weather forecast centre

Within the framework of co-operation in scientific and technological research, eighteen European countries have agreed to set up in Britain a European Meteorological Computing Centre. The objective of the centre will be to carry out research into forecasting for periods of four to ten days ahead and eventually to produce routine forecasts for these periods for issue to the national meteorological services in Europe and beyond.

The centre will require the use of a very powerful computer and, for this reason, it will be established initially at the Bracknell Met. office and will make use of an IBM 360/195 computer recently acquired by this establishment and recognized to be one of the fastest in the world. The centre will later move to new accommodation to be built at Shinfield Park, Reading, and will be equipped with the most modern computing and communications facilities available. The centre will be manned by an international staff of about 120 scientists, systems analysts and data processing staff.

The Meteorological Office at Bracknell has been carrying out research into medium term weather forecasting for a number of years. To a great extent this effort will be merged into that of the new European centre.

One stage in the manufacture of the new M9 memory units used in Honeywell's series 2000 computers. Dual-in-line i.cs are being assembled to a printed circuit board prior to flow soldering.



IEA Exhibition — 1974

The tenth International Instruments, Electronics and Automation Exhibition will be held at Oympia, London, from 13th to 17th May 1974. The exhibition, which takes place biennially, was last held in 1972 when more than 700 companies from 22 countries were represented. The exhibition forms part of a regular cycle of international exhibitions presented in different years in Dusseldorf, Paris and Milan. Exhibits eligible for inclusion will be: all classes of professional and industrial electronics; laboratory, scientific and process control instrumentation; machine tool controls and automation equipment; computers and data handling equipment; electronic and other components, materials, services and ancillary equipment.

Gramophone golden jubilee

Congratulations to the music and audio monthly magazine *Gramophone* on reaching its 50th birthday! To commemorate the occasion, the April issue contains — as its front section — a replica of the first edition published in 1923.

Higher power Gunn diodes

The microwave output power obtainable from Gunn diode oscillators is usually in milliwatts — being limited by low conversion efficiencies of typically a few per cent and by problems of heat removal from the active region of the devices. Now Mullard, in their research laboratories at Salfords, Surrey, have produced experimental devices giving c.w. powers of 1 watt at 3% efficiency in the 7GHz region. This performance has been achieved by attention to the quality of the cathode contact and of the heat sink — the main factors limiting output power.

A. F. Bulgin are celebrating their golden jubilee, and marking the occasion is the above advertisement for their first product, a battery switch.

For improvement of contact the technique adopted has been to optimize each of the processing stages — GaAs surface preparation, evaporation conditions, metal composition, definition of contact areas and alloying of the contact — in terms of their effect on the saturation current, as determined from the short-pulse current-voltage characteristic, and on the structure of the metal-GaAs interface. Improvement of heat-sinking has been obtained by alloying the devices to the pin of the package by means of an intermediate alloy layer. Devices made using the metal contacts and alloyed heat sinks are claimed to have manufacturing advantages, to be highly reproducible and to have microwave properties comparing favourably with those of epitaxially contacted devices.

Briefly

Coals to Newcastle. Bi-Pre-Pak have sold 1,000,000 transistors to the inscrutable dealers of Hong Kong.

Ultimate in accuracy? The absolute accuracy spec. of the Hewlett-Packard 5061A cesium beam primary frequency standard has been improved from ± 1 part in 100,000,000,000 to ± 7 parts in 1,000,000,000,000!

Montreux TV symposium. The eighth biennnial International Television Symposium and associated engineering exhibition to be held in Montreux opens on May 18th for a week. One hundred papers from 12 countries are listed for presentation.

An audio department store is to be officially opened by Lindair in Tottenham Court Road, London, at the beginning of May. An important inclusion is a 2000 sq.ft. studio in the basement for stereo and 4-channel demonstrations.

A Digital Multimeter

3 — Construction

by D. E. O'N. Waddington, M.I.E.R.E.

In the previous parts of this article I have described the various units which go to make the multimeter. In this section I will describe how they are connected together and how to set them up.

The interconnexion of the blocks occasioned a lot of thought as I was torn between the "minimum knobs" philosophy and the desirability of making it possible to subdivide the instrument into its major functions. The latter consideration won so that, in its final form, the instrument has two function switches, one for the Frequency/Time/Period (FTP) section and the other for the Voltage/Resistance/Capacitance (VRC) section, each having a position which transfers control to the other. Similarly there are two range switches. Actually, this decision to split the instrument into two sections simplified the switches and wiring considerably and, I feel sure, reduced many of the problems which otherwise might have arisen. Not the least of these is ensuring that the wiring is correct.

Table 1 shows how the function switches are arranged. If the FTP function only is required, all that is necessary is to delete the VRC position on S_2, reducing this to a three position switch, to delete S_4 and to permanently wire the connexions required for S_4 position 4. In practice this will only be S_{4a}; the other connexions will not be needed as the relevant sections will have been omitted anyway. A similar exercise could be carried out if only the VRC functions were required.

The wiring of S_2 is not at all critical as the leads to it only carry d.c. However, the wires to $S_{4e,f,g,h}$ are more sensitive. Hum pick up on S_{4e} or S_{4h} could be a problem, so it is advisable to keep these away from the power supply section. Stray shunt capacitance or resistance could prove troublesome on $S_{4f,g}$, and, to connect the capacitance-measuring circuits, short stiff wires should be used, positioned so that they are not close to any other wires or to the chassis. If possible, use a low-leakage switch wafer.

The functions of the two range switches are shown in Table 2. The wiring of the FTP range switch is non-critical. It will be seen that the first position of this switch, when used for frequency measurement, is called "Test" and is used to check the filaments of the indicators. With the switch in this position, the indicators should all show "8". This position would imply that there is an effective full scale range of 199MHz, which is well beyond the capabilities of the counter, so it is as well to inhibit its use in this way. Range indication is accomplished almost entirely by decimal point switching. I chose this method as it reduces the sign-writing on the front panel considerably!

The VRC range switch has a non-critical section, $S_{5a,b,c,d}$, and a section sensitive to hum pick up and strays, $S_{5\,e,d}$. In order to reduce these effects to a minimum, I mounted the input amplifier (Tr_1, Tr_2, IC_1 and associated components (Fig. 8 in Part 2) on the back of S_5 adjacent to $S_{5e,d}$, next to the a.v./d.v. switch S_6, and the input socket. The earth returns for R_3, C_3 and the wiper of S_{4e} are taken to the input socket earth to reduce errors which might be caused by earth currents. The attenuator resistors R_1, R_2, R_3, R_8 and R_9, determine the range-switching accuracy of the voltmeter, and fortunately, it is the ratios rather than the absolute values which are important. If at all possible, these resistors should be of the metal-film variety to achieve the best stability. Wire-wound resistors could be used but even with "non-inductive" windings the residual inductance would probably limit the upper frequency cut-off to a few kilohertz.

The "Prime" switch is used only for time measurement and should preferably be biased in the "off" position.

In general the interconnexion of the boards within the instrument is not critical but it is as well to observe the following precautions:

1. Wire the supply lines to each board with separate leads from the power supply so that there are no common supply paths.
2. Wire the earths separately to a common point at the junction of the chassis, centre tap of mains transformer, and input smoothing capacitors. The 5V earth should, of course go to its own stabilizer earth point.
3. Do not screen the FP input lead as this will impair the sensitivity at high frequencies.
4. Keep the lead from the capacitance

TABLE 1 Function switches

FTP

Function	VRC Position 1	Frequency Position 2	Time Position 3	Period Position 4	Wafer
time base selector	100kHz(7,1)	Time Range Switch (S_{1a})			$S_{2a.}$
control logic	5,2	5,3	5,2	5,2	$S_{2b.}$
control logic	5,11	5,11	5,11	—	$S_{2c.}$
control logic	5,10	—	5,10	—	$S_{2d.}$
control logic	5,4	5,4	—	5,4	$S_{2e.}$
decimal point (FTP)	—	S_{1b} wiper	S_{1c} wiper	S_{1c} wiper	$S_{2f.}$
decimal point (VRC)	S_{4b} wiper	—	—	—	$S_{2g.}$

Connexion notation — first number in brackets refers to Fig. No. in Part 2 of the article, second number to pin number on this diagram. E.g. (5,2) refers to one input to gate IC_{1a} is Fig. 5, Part 2.

VRC

Function	Voltmeter Position 1	R Position 2	C Position 3	FTP Position 4	Wafer
control logic/decimal point FTP	5,12	5,12	5,12	S_{2f} wiper	S_{4a}
decimal point VRC	S_{5a} wiper	—	S_{3b} wiper	—	S_{4b}
polarity indicators/A.D store	to lamps	—	9,4	9,4	S_{4c}
capacitance meter (store)	10,9	10,9	—	10,9	S_{4d}
voltmeter gain	S_{5f} wiper	—	—	—	S_{4e}
R/C current selector	—	S_{5c} wiper	S_{5d} wiper	—	S_{4f}
C/R input	—	$S_{4h}(2)$	10,6	—	S_{4g}
input amplifier (8,5)	S_{5e} wiper	$S_{4g}(2)$	E	E	S_{4h}

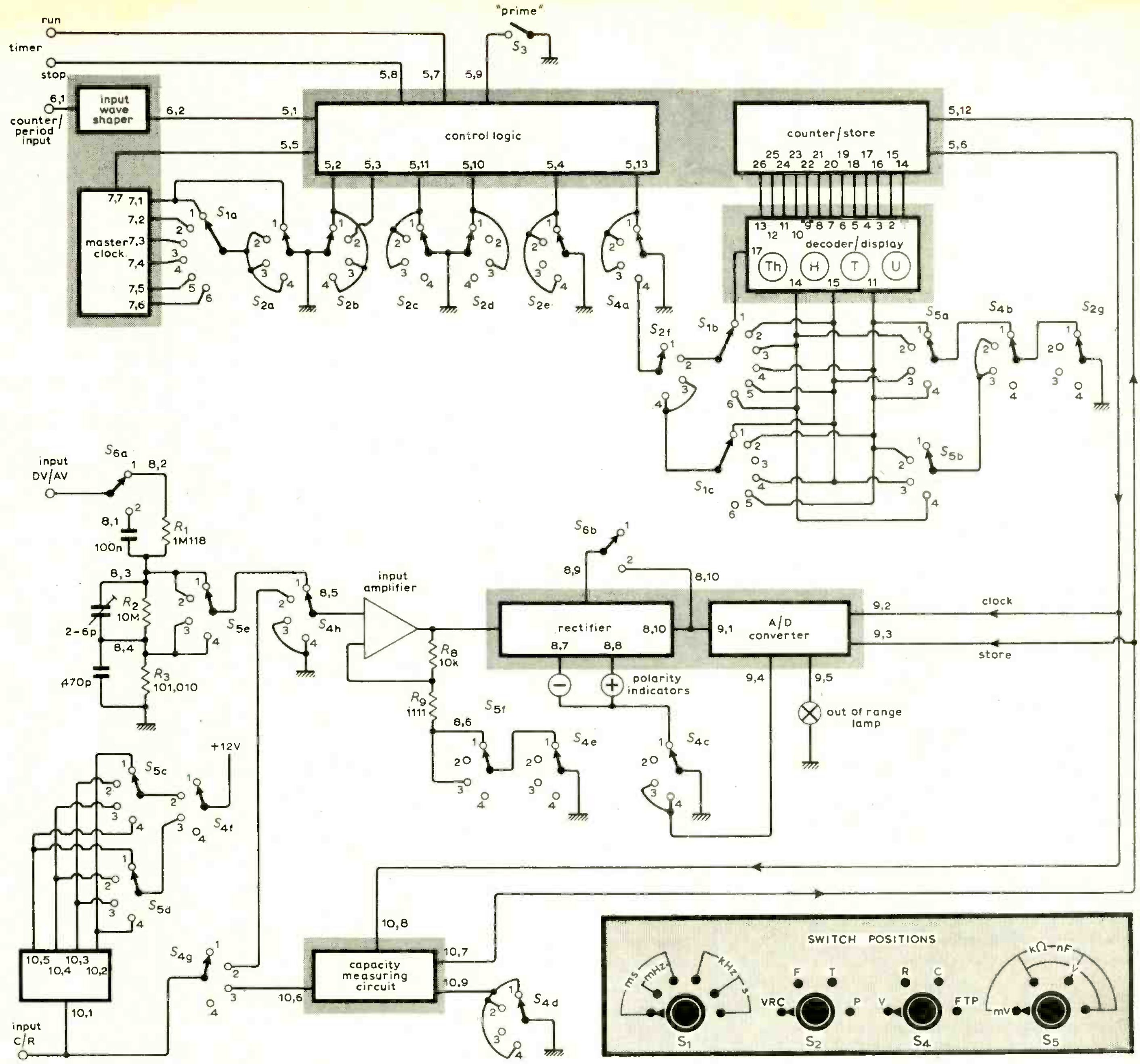


Fig 1. Interconnexion diagram.

measuring input terminal as short as possible to reduce strays. (My own prototype has a constant error of 24pF due to strays.)

It is most convenient to build the circuits on matrix board such as "Lektrokit" or "Veroboard". Avoid the types which have copper strips as it is extremely difficult to work out suitable wiring runs! Most of the components used in the instrument are generally available. The polarity indicator, however, had to be home-made as I could not find a suitable incandescent indicator. The construction of this indicator is shown in Fig. 2.

Before finally wiring the power supply to the other parts of the instrument it is as well to check that it is functioning correctly. To do this, connect a 220Ω 1W resistor from the +12V rail to earth and another from the −12V rail to earth. A 10Ω 5W resistor should be connected from

TABLE 2 Range switches

FTP

Function	Position 1	Position 2	Position 3	Position 4	Position 5	Position 6	Wafer
frequency	test		MHz		kHz		
time		milliseconds			seconds		
period		milliseconds			seconds		
select time		10kHz	1kHz	100Hz	10Hz	1Hz	S_{1a}
base	100kHz						
dec. point frq.	—	4,15	4,14	4,16	4,15	4,14	S_{1b}
dec. point T/P	4,15	4,16	—	4,15	4,16	—	S_{1c}

VRC

Function	Position 1	Position 2	Position 3	Position 4	Wafer
voltage	mV		V		
resistance			kΩ		
capacitance			nF		
dec. point volts	4,16	4,14	4,15	4,16	S5a
dec. point R/C	—	4,16	4,15	4,14	S5b
current source (R)	10,2(1μA)	10,3(10μA)	10,4(100μA)	10,5(1mA)	S5c
current source (C)	10,5(1mA)	10,4(100μA)	10,3(10μA)	10,2(1μA)	S5d
voltmeter input att.	8,3	8,3	8,4	8,4	S5e
voltmeter gain	8,6	—	8,6	—	S5f

the +5V rail to earth. These resistors simulate the operational loads on the regulators. Monitor the +12V rail and set it to be correct ± 1% using R_8 in Fig. 3 of Part 2. The negative rail should now be −12V ± 1% provided that R_{10} and R_{11} have been selected to be equal. The 100Hz ripple on these rails should be less than 2mV p-p. The voltage on the 5V rail should be correct to within ± 5% and the ripple should be less than 50mV p-p. Excessive ripple will indicate either that the input voltage to the regulator is too low or that C_3 is not completely effective. When it is ascertained that the power supply is working correctly, wiring should be completed and the instrument is now ready for setting up.

Setting up

This is far less difficult than the complexity of the instrument would suggest. The test gear required falls into two categories, setting up and calibration.

The former consists of the following: an oscilloscope (preferably d.c. to 6MHz), an Avo or equivalent meter, a signal source, (1kHz, 10kHz, 50kHz), and a d.v. source (1.5V-nominal torch battery). Calibration equipment includes: a frequency standard, a known d.v. source, known 1kΩ, 10kΩ, 100kΩ and 1MΩ resistors, and a known capacitor 100μF. The standards need not necessarily be accurate provided that their values are known accurately.

It is most convenient to start by checking the FTP aspects of the instrument as this section should require the least adjustment. Pin numbers, for example 7,2, refer to the Fig. number in Part 2 of the article (7) followed by the pin on that diagram (2).

Master clock This circuit, shown in Part 2, Fig. 7, should be tested first as it provides the timing signals for the rest of the instrument. Set the switches as follows:
VRC function switch S_4 to "FTP".
FTP function switch S_2 to "Frequency".
FTP range switch S_1 to position 1.

The clock output at 7,7 should be an approximate square wave with an amplitude of 5V p-p and a frequency of 100kHz. If standard frequency source is available, the crystal frequency may be set to precisely 100kHz by adjusting C_1. The best way to do this is to apply the standard to the y input of the oscilloscope and the crystal oscillator output to the x input and to set the x and y gains to produce a Lissajous figure, adjusting C_1, to give a stationary picture. The standard need not necessarily be 100kHz; any integral multiple or sub-multiple, provided that it is not more than 10 times, can be used. Using this method it is possible to set the frequency to be correct to within less than 0.1Hz (1 part in 10^6). If no frequency standard is available, the best approach is to replace C_1 and C_2 by a fixed 50pF capacitor, when the crystal frequency will be correct to within about ± 3Hz.

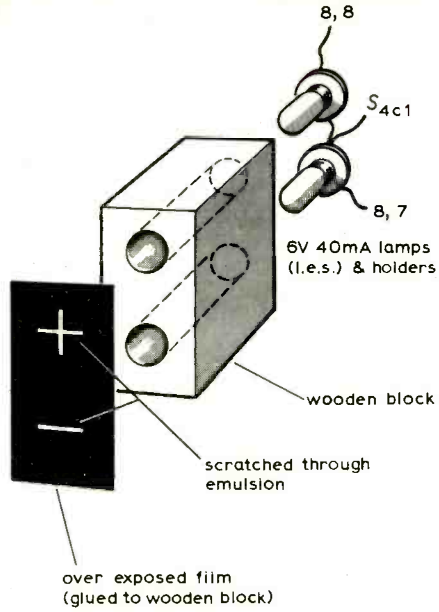


Fig 2. Polarity indicator construction.

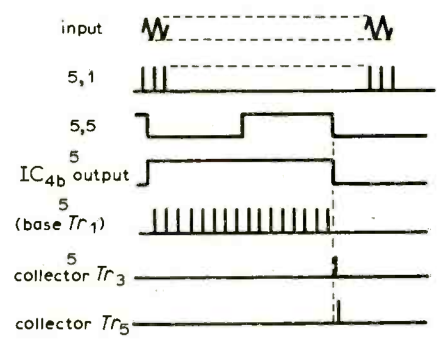


Fig 3. Counter waveforms.

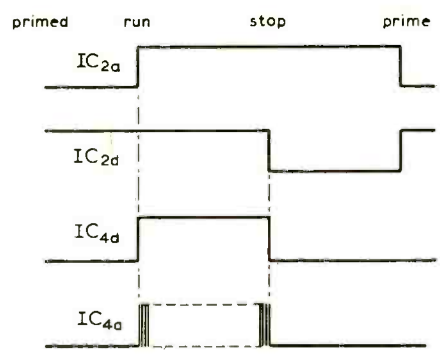


Fig 4. Timer waveforms.

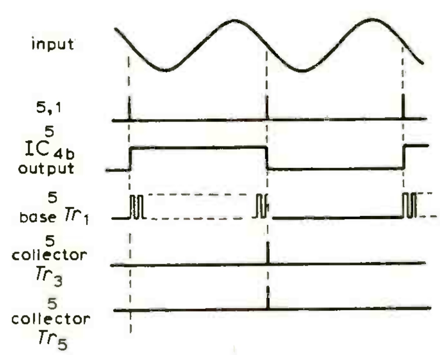


Fig 5. Period meter waveforms.

Set the FTP range switch successively to its other five positions and check that, at each step, the frequency of the output at 7,7 decreases by a factor of ten.

Input Wave Shaper. Monitor the output at 6,2 on the oscilloscope. Connect a signal of approximately 100mV to the Counter/Period input. If possible the signal should have a frequency of the order of 1MHz but 1kHz can be used, provided that the oscilloscope has a trigger level control. The output should consist of positive-going pulses having an amplitude of 5V and a width of approximately 170ns. If a low test frequency is used, it will be virtually impossible to see these pulses on the oscilloscope screen because of the small duty cycle. However, by adjusting the trigger level control, it should be possible to detect that the output is present even if it cannot be measured by setting the trigger level so that, when the signal is present, the time-base just triggers. When the signal is disconnected, the time-base should no longer fire.

Decoder/display. There are really no tests which can easily be carried out on this section. The indicators can be checked to ensure that all of the segments are wired to the decoders (SN 7447N) and that they all light by setting the FTP range switch to position 1 and the FTP function switch to "Frequency". All segments should now light except for the most significant digit which may be 1 or 0. This test, however, only shows that all wires are connected but not that they are necessarily correct. Crossed connexions only show up later when indecipherable digits appear!

Counter, store, control logic and timer control. This should be tested by checking each of the three functions, Frequency, Timer, Period.

Frequency. Set the FTP range switch S_1 to position 6 and apply a signal of approximately 1kHz at a level of about 1V to the Counter/Period input. The waveforms should be as shown in Fig. 3 and the display should show the frequency in the form 1.000kHz. The waveforms at the collectors of Tr_1, Tr_3 and Tr_5 will probably not be discernible on the oscilloscope but their presence may be verified by checking that they trigger the time-base as described above.

Timer. Set the FTP function switch to "Time", the FTP range switch to position 4 and depress the "Prime" switch S_3. The conditions shown at "1" in Fig. 4 should then exist. Connect the "Run" input to ground and check that the conditions are as shown at "2" in Fig. 4. Connect the "Stop" input to ground, when the display should show the time interval between earthing the two inputs.

Period. The method of checking this function is similar to that used for checking the frequency counter except that it is advisable to use a low input frequency such as

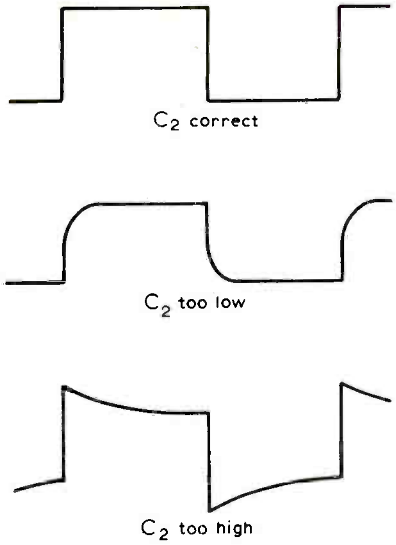


Fig 6. Setting frequency response using a square wave.

50Hz and to set the range switch to position 2. The display should show 020.0. The waveforms are shown in Fig. 5.

As shown above, there is virtually no setting up required for the FTP functions, only checking that it all works! However, if any function does not work, suspect the wiring first of all as this is the main cause of non-working digital circuits. I know that this should be obvious but the wiring here is slightly more complex than usual, mainly because of its quantity and the fact that it is interconnexion between similar "black boxes". If the wiring is correct, however, and things still refuse to work, the only course is to check waveforms throughout the circuit working methodically from the inputs to the outputs.

The VRC functions of the instrument require a great deal more setting up as they rely on linear rather than digital circuits for their operation.

Voltmeter. Set the controls as follows: FTP function switch S_2 to "VRC", VRC function switch S_4 to "V", VRC range switch S_5 to position 2, and d.v./a.v. selector S_6 to "a.v.". Short the input connexions, and set R_{15} (Fig. 8, Part 2) to mid-travel.

Monitor the voltage at 8,10 and adjust R_5 so that the voltage at this point is as near to zero as possible. Short point 8,10 to earth. Monitor point B, (Fig. 9 Part 2) with the oscilloscope and adjust R_{11} so that the amplitude of the triangle waveform seen at this point is as near to zero as possible but still present. (This compensates for the offset voltage of IC_4.) Remove the short circuit from 8,10 and re-adjust R_5 so that the triangle amplitude is again as small as possible but still present. Set the a.v./d.v. switch to d.v. and apply a direct voltage of between 1 and 1.9V to the input. Note the reading on the display (x). Reverse the polarity of the input and note the reading on the display ($-y$). Adjust R_{15} (Fig. 8) so that the display shows $(x + y)/2$. Repeat these two steps until $x = -y$.

Apply a known voltage of between 1 and 1.9V to the input and set R_2 Fig. 9 so that the instrument indicates the correct voltage.

The waveforms to be expected in the circuit of Fig. 9 are shown in Fig. 9a.

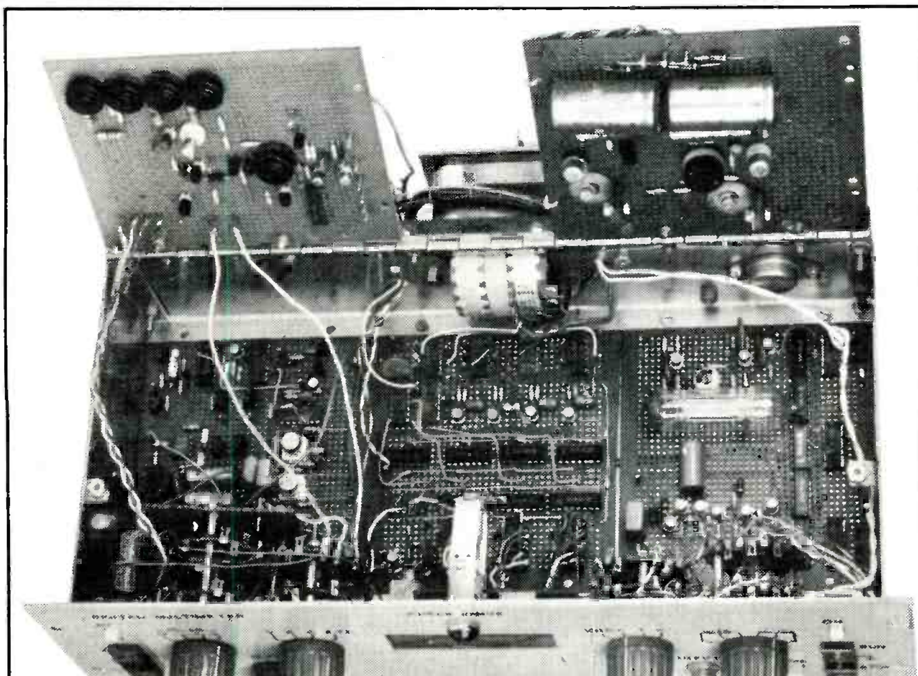


Fig. 7. Interior of multimeter. The two "opened-out" boards are the resistance/capacitance circuit (left) and the power supply stabilizers. The three boards in the chassis are, left to right, voltmeter, control logic and master clock/input shaper.

Semiconductors

Power Supply

T_{r1}	BC109	T_{r7}	2N2904
$T_{r2,3,5}$	BCY72	D_{14}	1N4001
T_{r4}	BC108	D_5	BZY886V8
T_{r6}	2N2218	IC_1	LM309K

Display

T_{r10}	BC108	IC_{1-3}	SN7447N

Indicator FUJI MINITRON 3015F (supplier KGM Electronics)

Counter, store, control logic, timer control

T_{r4-5}	BSX20	$IC_{1,4}$	SN7403AN
$IC_{2,5,6,14}$	SN7400N	IC_3	SN7472N
$IC_{7,8,9}$	SN7490N	IC_{10}	SN7473N
IC_{11-13}	SN7475N		

Input wave shaper

$Tr_{1,2,3}$	BC108	$T_{r4,5,6}$	BSX20

Master clock and divider

$T_{r1,2}$	BC108	T_{r3}	BSX20
IC_{1-5}	SN7490N	gates	DTL946

Input amplifier, rectifier and polarity indicator

$T_{r1,2}$	TIS68	$IC_{1,3}$	μA741
$T_{r3,4,5}$	BC108	IC_2	N5556
T_{r6}	BCY72	$D_{1,2}$	1N4148

A.-to-d. converter

$T_{r8,9}$	BF244B	IC_4	μA741
$T_{r10,11}$	BC107	IC_5	SL702C9 (Plessey)
$T_{r12,15}$	BSX20	IC_6	SN7400N
$T_{r13,14}$	2N2894	IC_7	NS7402
T_{r16}	BC108	D_3	1N821, 1N823, 1N825
T_{r17}	BCY72	D_{4-11}	1N4148

Capacitance/resistance measuring circuit

T_{r1}	BC252C	IC_1	DTL930
$T_{r2,3,4}$	BF244B	D_1	BZY88C4V7
T_{r5}	BC107	D_2	1N4148
$T_{r6,9}$	2N2894	D_3	BZY88C8V2
$T_{r7,8}$	BSX20		

Semiconductor equivalents

BC107	BC171, BC207, BC237, BC507
BC108	BC172, BC238, BC508, BC208
BC109	BC173, BC239, BC209, BC509, 2N2484
BCY72	BC205, BC308, BC405
BSX20	2N2369
2N2218	2N2219, 2N4918
2N2904	2N2905, 2N4921
TIS68	FM3958 (National Semiconductors. Connect the substrate to OV)
BZY88C4V7	ZW4.7, Z5B4.7, HS7047
BZY88C6V8	ZW6.8, Z5B6.8, HS7068
BZY88C8V2	ZW8.2, Z5B8.2, HS7082
SN7400N	FJH131, FLH101
SN7402N	FJH221, FLH191
SN7403AN	FJH301A, DTL946
SN7447N	9317 (Fairchild)
SN7472N	FJJ111, FLJ111
SN7475N	FJJ181, FLJ151
SN7490N	FJJ141, FLJ161
DTL946	MC846, (SN7403N, FJH301A with 2.2k pull-up resistors)
N5556	MC1556
2N2894	MPS3640
1N4148	1N914, 1S44

When the d.v. aspects of the voltmeter have been set, the only aspect of a.v. measurement to be set is the frequency compensation of the input attenuator. This is probably most easily done using a square wave but a sine wave method can be used as an alternative.

Square wave method. Set the a.v./d.v. switch to a.v. Set the VRC range switch to position 3. Apply a 1kHz square wave with a peak-to-peak amplitude of between 6 and 20V to the voltmeter input. Look at the output at pin 6 of IC_1 with the oscilloscope. Adjust C_2 to obtain the best possible square wave. See Fig. 6.

Sine wave method. This is only valid if the output level of the sine wave can be relied on to remain constant regardless of frequency.

Apply a 1kHz signal of approximately 10V r.m.s. to the input and note the reading on the display. Set the frequency to 50kHz and adjust C_2 to restore the reading. Some frustration with this method can be avoided if one takes the precaution of disconnecting C_4 (Fig. 8) thus speeding the settling time of the instrument.

Resistance measurement. To set up the resistance ranges, some accurate resistors are essential. The preferred values for this test are 1kΩ, 10kΩ and 100kΩ and 1MΩ, and the procedure is as follows: set the VRC function switch S_4 to "R", set the VRC range switch to S_5 to position 1, connect the 1MΩ resistor between the R/C terminal and earth and adjust R_1 so that the display shows 1000.

Set the range switch to position 2 and with the 100kΩ resistor connected between the input terminals set R_3 so that the display shows 100.0.

Carry out the same procedure for positions 3 and 4 using the 10kΩ and 1kΩ resistors and setting R_5 and R_7 to obtain readings of 10.00 and 1.000 respectively.

Capacitance measurement. Once the resistance meter has been set up there is only one adjustment for setting up all the ranges. I set up the 199.9 nF range because I had access to a 150 nF $\pm$ 0.25% capacitor, but it should make little difference which range is used for calibration. However as there will be stray capacity across the input terminals, it is probably as well to do the setting up on a high rather than a low range. The procedure is as follows: set the VRC function switch S_4 to "C", set the VRC range switch S_5 to suit the standard capacitor being used, and adjust R_{17} (Fig. 10, Part 2) until the display shows the correct value. All of the capacitance ranges are now calibrated.

If this setting up procedure is followed and if the standards are stable, the instrument should now meet its specification.

Correction

(a) In Fig. 9 of Part 2 of the article, Tr_8 and Tr_9 were incorrectly shown as BC2 448. They should be, as shown in the component list above, BF244B. (b) Fig. 11 was, we thought, amusing but unhelpful. We apologize for the mirror-image and print it again the right way round.

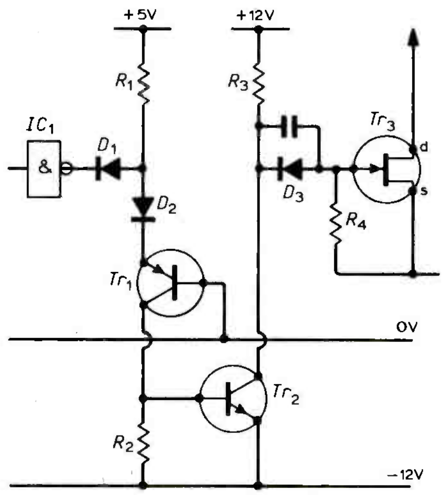


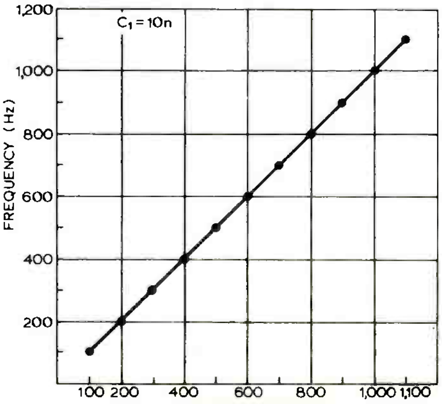
Fig. 11. Method of driving f.e.t. switches from 5V lines.

Correction

We regret the introduction of several errors in the article on a **"Versatile Triangle Wave Generator"** in the February issue. In the third column on p.87 the numerator in the expression should be "I" not "1". A draughting error in Fig. 4 made nonsense of the author's statement that "the frequency can be read straight from the Helipot dial as shown in Fig. 4". The redrawn figure is reproduced below. In the second paragraph of the constant current generator section (p.88) Tr_2 should read Tr_{12}, and, in the last line of this page, R_2 should read R_3.

The components lists apply to Figs. 2 and 3 and Fig. 7.

The author points out that although he used a 2N4061 any silicon p-n-p transistor could be used.



Books Received

The following is a selection of books from a new series for those interested in electronics and allied subjects. The first list of books, which originate from America, contains twenty titles and the books are published by a new imprint Foulsham-Tab.

Transistor Circuit Guidebook by Byron Webs contains practical circuits from tuners and amplifiers to test equipment and counter circuits. Pp.219. Price £1.20.

Beginners Guide to TV Repair by George Zwick provides instruction in the basics of television to help the beginner understand how a TV receiver works, what may go wrong with it and how it should be serviced. Pp.171. Price £1.00.

Advanced Radio Control by Edward L. Safford Jr, discusses the fundamentals of advanced radio control and describes the basic systems used. Pp.192. Price £1.00.

How to Read Electronic Circuit Diagrams by Robert M. Brown and Paul Lawrence contains a guide to translating circuit symbols, information on the components they represent and about the circuits in which they are used. Pp.189. Price £1.30.

All these books are published by Foulsham-Tab Ltd, Yeovil Road, Slough, SL1 4JH.

Logic and Logic Design by B. Girling and H. G. Moring is an introduction to Boolean algebra and its application to the fields of switching circuits, the solution of logic equations, the logic design of digital circuits, sequential machines and synchronous logic. It covers the computer science requirements for a B.Sc. degree. Using modern mathematics, the authors concentrate on the logical concepts involved rather than their implementation so that no detailed electronic circuitry is included. The book will be of value to science and engineering students whose courses include applied Boolean algebra. Pp.328. Price £5.80. Intertext Publishing Ltd, 24 Market Square, Aylesbury, Bucks.

Sound with Vision: Sound Techniques for Television and Film by E. G. M. Alkin is concerned with the art and craft of sound operations in association with television picture production. The book is intended primarily for the instruction of television sound operators and in describing technical subjects, a basic knowledge of electronics is assumed. The subjects covered are also of increasing interest to the film-making industry in the light of current trends and developments. The book discusses the problems encountered in the simultaneous production of sound and pictures, giving practical instruction in methods of solving them and examines the philosophy of equipment designed to meet the resulting requirements. This work is intended to be complementary to existing literature on sound and to avoid duplication. Where subjects are already fully documented, references are given. Although dealing mainly with sound in television, the subject matter also covers many aspects of film sound technique. The book is split into four parts (1) fundamental considerations (2) microphone technique for continuous take production (3) technical facilities and (4) sound operational practice. Pp.283. Price £6.00. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

Meterless Transistor Tester

A portable instrument capable of resolving current gain and leakage

by J. Lewis, B.Sc.

A need arose in the workshop for a portable, compact and reliable transistor tester which could be used to check all types quickly and also give an accurate value of h_{FE}. In the interests of economy and durability it was thought that perhaps an instrument without a meter would be preferable. Of the many described in the usual literature only one was found which readily fitted the specification—that described by D. E. O'N. Waddington*. This tester used a meter, though not in the normal current measuring configuration, as it measured the voltage developed across the emitter resistor. Fig. 1(a) shows the usual type of circuit used in which a known base current is injected into the transistor under test and the resulting collector current is measured by a suitably calibrated meter. In Mr Waddington's design Fig. 1(b) the meter is used as a voltmeter the reading of which is proportional to the current flowing through the resistor R_E.

The theory of this circuit was fully developed in the original article; an alternative approach is used here to describe the operation of this particular instrument.

In the common collector configuration (Fig. 2)

$$I_E = I_B(h_{FE}+1)$$

also $$I_E = \frac{V_E}{R_E}$$

and $$I_B = \frac{V_A - V_B}{R_B}$$

Therefore, combining the above gives:

$$\frac{V_E}{R_E} = \frac{V_A - V_B}{R_B}(h_{FE}+1)$$

If we neglect V_{BE} for the moment, $V_B = V_E$ and rearranging we get:

$$\frac{R_B}{R_E} = \frac{V_A - V_E}{V_E}(h_{FE}+1)$$

V_A and V_E can be conveniently chosen so that

$$\frac{V_A - V_E}{V_E} = 1$$

(in the prototype, $V_E = 2V$ and $V_A = 4V$)

Provided $h_{FE} > 20$

$$h_{FE} \approx \frac{R_B}{R_E}$$

Further development

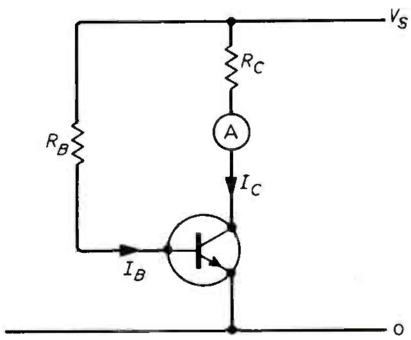
If R_B is chosen to be a linear variable resistor of, say, 250kΩ and R_E is 1kΩ then the h_{FE} can be measured directly on a scale calibrated from 0–250 over which a pointer attached to R_B rotates. In operation a voltmeter monitors the voltage developed across R_E whilst R_B is gradually increased in value, the gain being the scale reading when the meter registers 2V. The meter can be dispensed with and an op-amp used as a voltage comparator connected in its place which then compares the voltage across R_E with a suitable reference. The circuit for an op-amp being used as a voltage comparator is given in Fig. 3 and the threshold or triggering voltage E_T is determined by the values of R_1 and R_2 such that

$$E_T = -\left(E_{ref}\frac{R_1}{R_2}\right)$$

The prototype used a mercury cell, e.m.f. 1.4V, as the reference and since the threshold voltage had already been chosen as 2V, suitable values for R_1 and R_2 were 3kΩ and 2.1kΩ respectively. Of course, the reference voltage has to be of opposite polarity to the threshold voltage and a suitable switching circuit has to be used for n-p-n or p-n-p devices.

A breadboard of the simple circuit described above was made and proved excellent and it was then decided to extend the usefulness of the instrument by incorporating various refinements—these are extras of course, and can be omitted. R_B was made a variable 50kΩ resistor with a number of

*"Transistor Tester", *Wireless World*, June 1970.



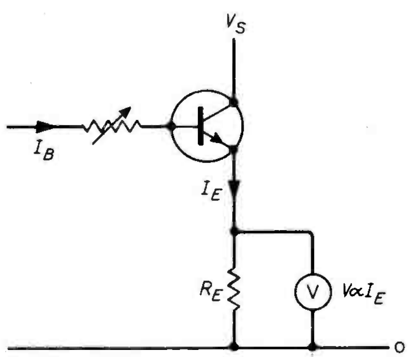


Fig. 1. Alternative measuring techniques.

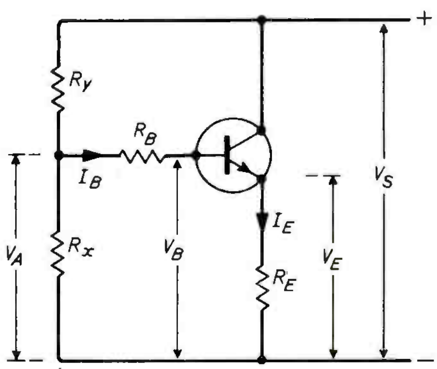


Fig. 2. The common collector configuration.

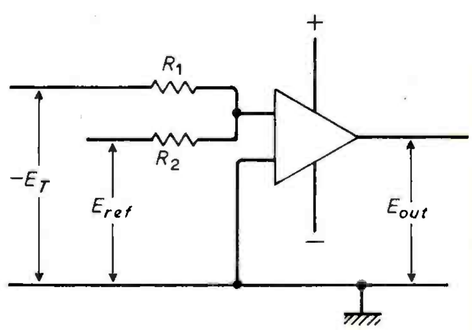


Fig. 3. Voltage comparator.

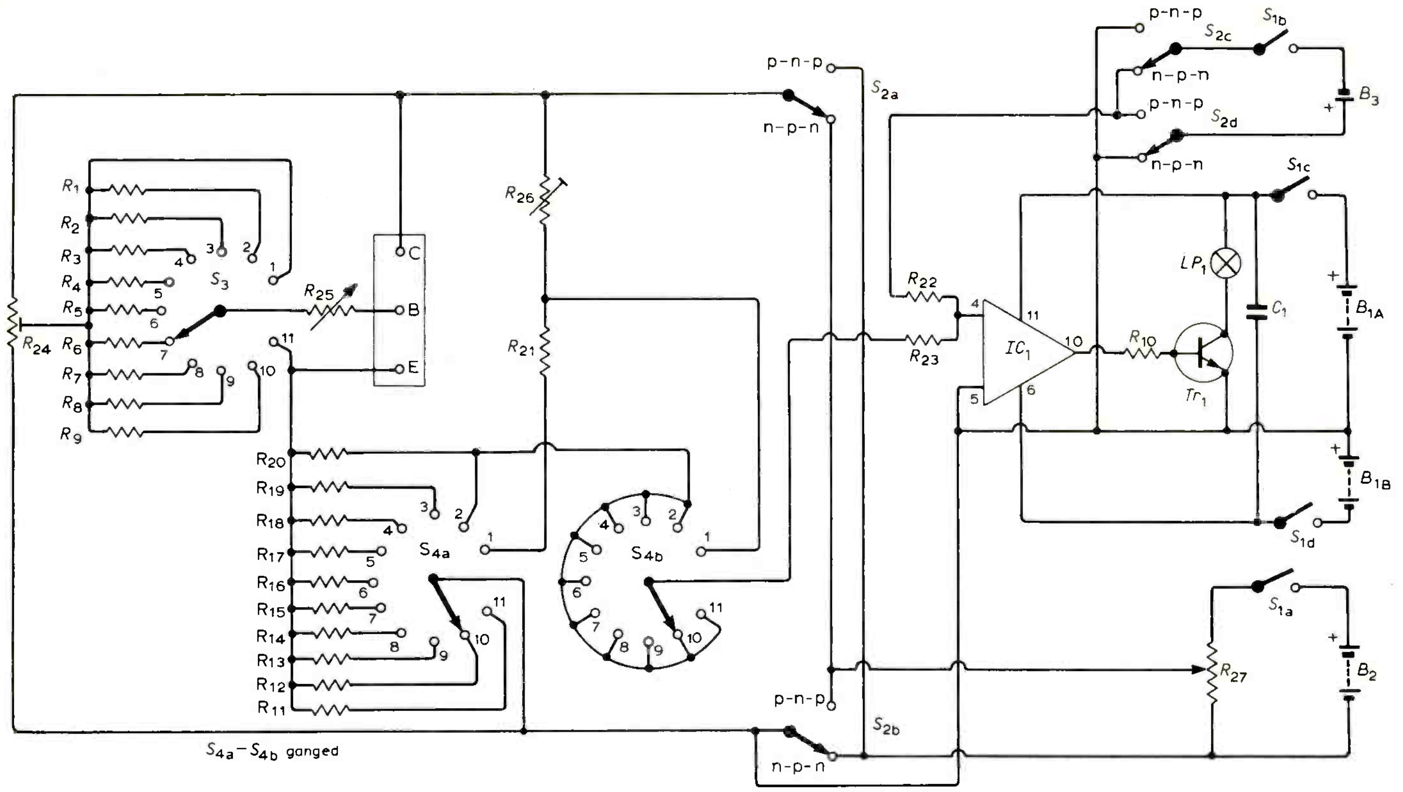


Fig. 4. Circuit diagram of tester.

fixed resistors—all multiples of 50kΩ—which could be switched in series with the variable one, thus extending the range and giving better resolution. In some cases it is desirable to know h_{FE} at different collector currents and in order to measure this, whilst also providing an indication of leakage, the emitter can be connected to a number of different resistors all providing a different function. Since these vary from the original 1kΩ value, a factor has to be introduced for each one by which the gain reading is multiplied. The values of these extra resistors and their factors are given in Table 1.

The prototype fitted easily into a diecast box, $7\frac{1}{2} \times 4\frac{1}{2} \times 3$in. The layout does not appear critical. The resistors were mounted on tag strip whilst the op-amp was fitted, crudely, onto turret tags. The batteries are held in position by sponge. On the lid were mounted the controls together with two sets of sockets to cater for the different base, collector and emitter lead layouts in both TO-5 and TO-18 sizes. Spring terminal posts cater for the odd devices which won't fit into the sockets.

The calibration of the instrument initially is critical if consistent results are required. It is necessary to set V_A accurately and a variable resistor R_y is adjusted until the potential is correct. A compromise has to be made here to allow for the V_{BE} of the devices. In the prototype Fig. 4, V_A was set at 4.4V using R_{24} though there is no reason why a switch could not be provided to allow one to choose either the relevant value for germanium or silicon transistors. V_s is set at 8V using R_{27}. The markings for switch position number are given in Table 1 for S_4 and Table 2 for S_3. The test position is calibrated using R_{26} until the voltage across R_{21} is 2V.

The scale for h_{FE} is marked out using a suitable ohmmeter across R_{26} which is disconnected from the circuit. At 5kΩ mark 0.1, at 10kΩ mark 0.2 etc. With S_4 at test, the indicator light should be off if S_2 is in the p-n-p position. R_{27} is rotated until it comes on and then backed off until it just extinguishes. If one now switches to n-p-n the light should remain out though a slight turn either way should bring it on. If this does not work check that 8V is available at the collector terminal C.

Operation

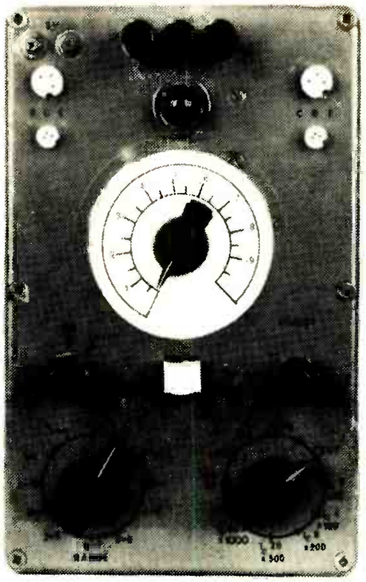
To use the tester one first has to set the voltage V_s by adjusting R_{27} as outlined above. The transistor is plugged in and S_2 put to the correct position. R_{25} is then adjusted in conjunction with S_3 until, with n-p-n devices, the light comes on, or, in the case of p-n-p ones, it goes out. The value of h_{FE} can then be read off using the correct

TABLE 2

S_3 position	Function
1	h_{FE} = 0–1
2	h_{FE} = 1–2
3	h_{FE} = 2–3
4	h_{FE} = 3–4
5	h_{FE} = 4–5
6	h_{FE} = 5–6
7	h_{FE} = 6–7
8	h_{FE} = 7–8
9	h_{FE} = 8–9
10	h_{FE} = 9–10
11	I_{CEO}

TABLE 1

S_4 position	Function	h_{FE} Multiplying factor	Resistor value
1	TEST		connected to R_{26} and R_{21}
2	I_c = 2mA	×50	1kΩ
3	I_c = 4mA	×100	500Ω
4	I_c = 8mA	×200	250Ω
5	I_c = 20mA	×500	100Ω
6	I_c = 40mA	×1000	50Ω
7	I_{CEO} = 1µA		2MΩ
8	I_{CEO} = 10µA		200kΩ
9	I_{CEO} = 100µA		20kΩ
10	I_{CEO} = 1mA		2kΩ
11	I_{CEO} = 10mA		200Ω



A general view of the prototype tester. In the centre is the h_{FE} dial. The range switch is bottom left and emitter current selector, bottom right.

multiplying factors. A faulty transistor is shown by the light either remaining on or off over the full range.

Leakage current can be gauged by switching to I_{CEO} on S_3. The light will go off if the leakage is too great for n-p-n or conversely on for p-n-p. By switching to various values of S_4 an indication of the leakage current can be obtained by noting when the state of the lamp changes. To distinguish between unmarked n-p-n or p-n-p types, S_3 is turned so that the base is shorted to the emitter with R_{25} at 0. Switch alternately to p-n-p and n-p-n whilst slowly rotating R_{25}. The position of S_2 which gives a change in indicator state is the transistor type. Diodes may be checked by connecting them between the E and C terminals with S_4 in the 2mA position. When the cathode of the diode is connected to the C terminal the light should remain on when S_2 is switched from n-p-n to p-n-p, and if the anode is at this terminal the light should remain off when switching.

Once one has gained some familiarity with this tester it is surprisingly easy and quick to use. Transistors can be tested almost as quickly as they are plugged in. Should a simpler tester be required then S_3 and S_4 could be omitted making R_{25} 250kΩ and leaving just R_{20} in the emitter circuit.

Components list

Resistors

1	50kΩ	15	2MΩ
2	100kΩ	16	50Ω
3	150kΩ	17	100Ω
4	200kΩ	18	250Ω
5	250kΩ	19	500Ω
6	300kΩ	20	1.0kΩ
7	350kΩ	21	100Ω
8	400kΩ	22	2.1kΩ
9	450kΩ	23	3.0kΩ
10	1.0kΩ	24	220Ω miniature skeleton preset
11	200Ω		
12	2.0kΩ	25	50kΩ w.w., standard size
13	20kΩ	26	470Ω skeleton preset
14	200kΩ	27	1kΩ miniature carbon

All resistors should be either 1% tolerance or selected values.

Switches

1	4 pole, 2 way rotary
2	4 pole changeover, miniature lever key
3	1 pole, 12 way rotary
4	2 pole, 12 way rotary
C_1	0.1μF
IC_1	709 type op-amp, d.i.l. or TO5 package
Tr_1	BFY 50
LP_1	any suitable panel light with bulb rated at 6V, 60mA
B_1, B_2	suitably sized 9V battery
B_3	1.4V mercury cell (RM625H or similar)

World-wide Mobile Communications and Surveillance via Satellite

A conference dealing with long-haul aeronautical and maritime telecommunications and the use of such systems for surveillance, and the consequent traffic control ability, was held at the Institution of Electrical Engineers, London, on March 13th to 15th.

The conference got off to a sobering start with the opening address by Professor Sir Herman Bondi, Chief Scientific Advisor, Ministry of Defence, who suggested that the biggest gap now existing in communications generally is our "ignorance of ourselves", considering how little is known about how human beings actually influenced each other when communicating. He further considered redundant or peripheral information or, to use his words, "sweet nothings in conversation", as an entirely necessary function forming an adjuster of the "mood faculty", presumably controlling one's receptive ability during discussion. From this, Professor Bondi drew a necessary distinction between communicating on an impersonal, instructional basis and communicating on a more personal, conversational basis. The conclusion was that thought must be given, in this light, to what type of telecommunications link was really required. He further felt that all the expense and interest shown in the sphere of aircraft and shipping surveillance could be justified, on an information/instruction basis anyway, where continuously monitored conditions, in respect of aircraft flight paths and shipping lanes, are not yet normal.

Because of the technological difficulties encountered with airborne and shipborne environments, Professor Bondi viewed mobile communications as a leader in the field of satellite communications. This work was directed towards the least inconvenient and most practical solutions which will eventually affect our social environment.

In all, 33 papers were presented at the conference, many of which provoked lengthy discussion. An attempt to view the world wide interest and activity in perspective, a paper entitled "The institutional bottlenecks affecting mobile satellite communication", given by D. O. Fraser of the British Aircraft Corporation, was entirely successful and many of the points brought out ran like tracers throughout the conference.

Theoretical studies of systems were plentiful, although many parameters, at this stage of evolution, are tending to become standardized. These include frequencies to be used, number of usable channels, channel widths and system access capability.

Although satellite frequency allocations have been confirmed at the World Administration Radio Conference for Space Telecommunications in Geneva (1971), studies were presented on the subject of analytical and applied methods of selecting and proposing the range of what may be called optimum frequencies for use in ship or aircraft to satellite communications links.

Results of experimental work carried out using existing geostationary satellite systems such as Intelsat IV and the U.K. Skynet were presented, and these should go a long way in helping system designers and engineers to specify, knowingly, nearer to the optimum range of parameters in Aerosat or Marisat systems.

Details of progress of some institutional programmes and studies were given, firstly by Dr. J. Vandenkerkhove, of the European Space Research Organization, Netherlands, who put forward the findings of the design study for their Aerosat proposal for a satellite covering the Atlantic region. Later G. H. Booth, of the Communications Research Centre, Canada, gave a paper entitled "The Canadian/U.S. high power Communications Technology Satellite" which described a programme devoted to the advancement of technology for future generations of high power satellite systems. The C.T.S. should be launched in 1975 by the National Aeronautics Space Administration, U.S.A., and one significant point in the system is the use of the 11 and 14GHz band for earth station to satellite and satellite to earth station communication. This was of greater interest later when, further on in the conference, R. A. Bedford and S. R. Temple, both with the Directorate of Radio Technology, Ministry of Posts and Telecommunications, said it was likely that the Ministry would recommend the 11 and 14GHz bands for earth station to satellite links.

E. J. Martin, of the Communications Satellite Corporation, U.S.A., announced a Cosmat contractural agreement to provide a working satellite service for the U.S. Navy, from late 1975, which may, at a later date, provide communications in the L-band region (approximately 1550MHz) for the merchant services. Two satellites are involved in this system, giving multibeam coverage of the Pacific and Atlantic areas.

Throughout the entire conference questions relating to the whole philosophy of mobile communications were being asked. In an attempt to clarify the system requirement several papers were given, by prospective users of both Aerosat and Marisat systems, who pointed out that although the institutions represented at the conference had gone some way towards providing desirable specifications regarding a usable economic system, significant areas had been missed or glossed over. It was suggested that this was due, in part, to a lack of liaison between the working institution, who would presumably have heavy involvement with future operating agencies, and the aeronautical/maritime user.

The 197-page I.E.E. Conference Publication, No. 95, is available from Publication Sales Department, Institute of Electrical Engineers, Station House, 70 Nightingale Road, Hitchin Herts. The Price is £5.00 for members and £7.60 for non-members.

Circards — 6

Constant-current Circuits

Introducing the constant-voltage dual

*by J. Carruthers, J. H. Evans, J. Kinsler & P. Williams**

For every circuit using a constant-voltage element or sub-section there is a dual circuit based on constant-current properties. That such circuits are less common and often misunderstood is partly for historical reasons, stemming from the lack of sources of electrical energy having constant-current characteristics. One cannot draw out of stores a "5A 250mV-hour battery". A battery that will sustain a constant current into an arbitrary load is not physically realizable, since the electro-chemical processes involved define the e.m.f., the current then being inversely proportional to resistance.

Either capacitors or inductors may be used for temporary storage of energy, but the cost and size penalties of the latter are considerable. Capacitors store charge, having a p.d. proportional to the stored charge, and sustain that p.d. to a first order against varying current drain; until the drain results in a significant loss of charge. Even more important is that the generation, transmission and transformation of a.c. by the Electricity Boards are all constant-voltage processes. After rectification, the only form in which d.c. power can be produced efficiently and with freedom from ripple is as a constant voltage.

Thus all common sources of electrical energy approximate to constant-voltage characteristics and the majority of electronic circuits have been designed for this mode of operation. It is a fascinating thought that there should be as many current-operated circuits as voltage-operated ones, though they may be unfamiliar in shape. For example transistors would have to be operated in series, carrying comparable currents in each device but with progressively increasing p.ds moving from input to output in an amplifier, while the interstage coupling might be inductive. Conversely, where constant-voltage supply circuits use inductors to achieve particular effects, the corresponding circuits using capacitors would be attractive alternatives if constant-current supplies were available.

Each type of constant-current circuit seeks to achieve a constant current against variations in supply voltage, load resistance and ambient temperature as well as against component parameter changes. This will apply whether the supply is in the form of a direct voltage or an alternating current. In the former case, an intermediate step may be used in which the power is converted into a switched waveform before re-conversion to d.c., the method having high efficiency even when the load voltage is much less than the supply voltage (Fig.1). Alternatively the d.c. may be used to power an amplifier which because of the design of its output stage or by virtue of the feedback employed, delivers a current to the load controlled primarily by some signal voltage or current (Fig. 2).

Purely d.c. systems may also fall into this category with the a.c. signal replaced by a direct voltage/current (Fig.3) which can be fixed or variable depending on the application. (Fixed if a constant current is to be forced in a zener diode to define its operating point, variable where used to plot the characteristics of a transistor.) In addition, current control can be achieved by devising a two-terminal circuit to be interposed between source and load (Fig.4). If the circuit has a high dynamic resistance the current is then stabilized against supply and load changes. To apply such a circuit to a.c. supplies involves a number of difficulties, not least that such constant-current action is achieved only

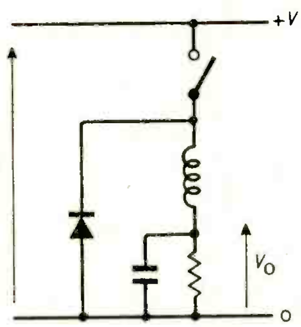


Fig.1. In trying to achieve a current constant against variations in supply voltage, load resistance, ambient temperature, and component parameters an intermediate step is sometimes used where power is switched before reconversion to d.c.

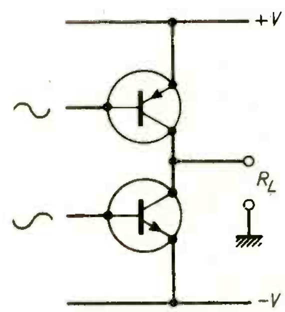


Fig.2. Another method of controlling load current.

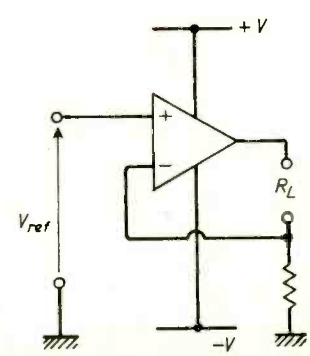


Fig.3. Technique of Fig.2 can be used with an a.c. signal replaced by a d.c. level.

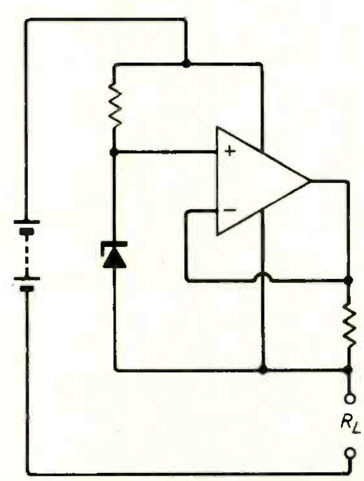


Fig.4. Current control can also be achieved by using Fig.3 as a two-terminal circuit between source and load.

*All at Paisley College of Technology

for that part of the cycle for which the input amplitude is in excess of some minimum value, typically 2 to 10V. It becomes particularly important to distinguish the parameter of the output whose constancy is being maintained. The peak value will be held constant by a two-terminal device having infinite slope resistance for amplitudes of input above the minimum. In many cases it may be necessary to rectify the applied voltage so that the ciruit deals with a single polarity.

Two further parameters of interest are the r.m.s. and mean-rectified output currents. For both, the rise in current during the pre-limiting region as the input voltage increases causes a rise in the area under the current graphs, i.e. in the mean/r.m.s. current. If the two-terminal network is arranged to have a negative-resistance characteristic then the current can fall back during input peaks, offsetting the tendency for the mean/r.m.s. currents to rise (Fig.5). A different value of negative resistance is required for the mean and r.m.s. conditions and it is further dependent on the input waveform. The method has the advantage that it operates on the instantaneous value of input, though methods based on thermistors and thermocouples might be used to monitor r.m.s. current via thermal effects. The necessary feedback would be more easily applied via conventional regulator circuitry and would involve thermal time delays that would not cope with input/load transients.

In the majority of these circuits the reference determining the current will be a voltage such as that developed across a zener diode. Where lower stability is adequate the p.d. across a forward-biased silicon p-n junction has advantages.

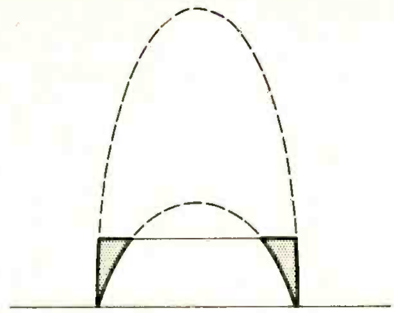


Fig.5. Negative-resistance causes current to fall back during input peaks, offsetting tendency for mean/r.m.s. currents to rise in the pre-limiting period.

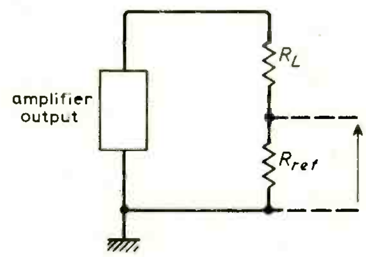


Fig.6. Circuits based on op-amps are generally limited to the case where loads do not require a ground connection.

The voltage, or some function of it, appears across a resistor defining the current in that resistor. If the load is placed in series with that reference resistor, or in some other circuit path carrying a related current, then load current is fixed. Operational amplifiers have one output terminal committed to ground potential. If the generator representing the output has to appear in series with the reference resistor and load to define the current then a conflict appears (Fig.6). To achieve a current flow to ground the reference resistor (and with it the reference voltage and its associated circuitry) would have to float. As this is inconvenient, circuits based on conventional operational amplifiers may be limited to constant-current operation only with those loads not requiring a ground connection.

Circuit configurations are possible in which negative and positive feedback can be combined to raise the output resistance to very high values. Penalties include relatively poor stability of this output resistance and difficulties in achieving high output currents. This last demand is frequently met by adapting existing voltage regulators with a reference resistor at the normal output voltage terminals and the true load in series with it as outlined above.

Finally, the problem of controlling alternating current may be tackled in a different way by means of thyristor switches. These can be fired at appropriate points on the input waveform such that the mean current in the load is controllable. As the thyristor behaves as an almost perfect switch, no control is exercised over the instantaneous value of current. A filter provides a feedback voltage proportional to the mean current and controls the phase angle of the firing circuit. This phase angle control is quite distinct from the frequency/pulse-width modulation methods that are inherent in the switching amplifiers described earlier, and filtering of the output waveform would not normally be applied. The method would be suitable for such applications as battery charging where the current waveform is uncritical.

Circards — future series

As already announced the trial period of Circards — the *Wireless World* information service on circuit design — has confirmed our hopes and the scheme is to be continued and extended.

We list below the subjects it is planned to cover in the next 10 sets of cards — although not necessarily in the order listed. The first (no. 6), which is discussed above, will be available on May 1st. The U.K. price per set is £1 and the overseas price £1.15 (airmail postage extra).

Many readers have asked if they may order sets of future Circards to be sent as published. We have therefore introduced a subscription rate for the next 10 sets (nos 6–15) which it is hoped to issue monthly. The subscription for the U.K. will be £9 and for overseas £10.50. Orders for individual sets or subscriptions should be addressed to J. Rider, IPC Business Press, Sundry Sales, 33-40 Bowling Green Lane, London EC1R 0NE.

Circards are currently zero rated for the purpose of V.A.T.

Constant Current Circuits: Regulating currents at high and low powers for load and bias purposes.
Power Amplifiers: Power Amplifiers, d.c., audio switching and r.f.
Opto-electronics: Generation, detection and processing of optical signals.
Basic Logic Gate Circuits: Practical gate circuits using m.o.s., t.t.l. and other logic families.
Astables: Generation of repetitive waveforms from low to high frequencies using i.c. and discrete circuits.
Micropower Circuits: Operation of amplifiers, oscillators and measurement circuits at very low voltages and currents.
Wideband Amplifiers: Amplifiers of varying power levels over wide frequency bands.
Alarm Circuits: Detection of fault conditions and control of alarm devices.
Pulse Modulators: Modulation of pulse waveforms for communication and instrumentation systems.
Digital Counters: Binary counters using a variety of logic families.

New readers may also like to know the subjects already covered in Circards:
1. Basic Active Filters; 2. Switching Circuits: Comparators and Schmitts; 3. Waveform Generators; 4. A.C. measurements; and 5. Audio Circuits: pre-amplifiers, mixers, filters and tone controls. These are still available from the above address at the same individual price quoted above (they are not available at the reduced subscription rate).

London Electronic Component Show

Exhibitors and exhibition details

The 23rd international component show to be held at Olympia, London from 22nd to 25th May will this year have 450 participant companies with one fifth of these participants coming from overseas. The show will be open daily from 09.30 to 17.30 and admission is 30p but is free to overseas visitors. Sponsor of the show is the Radio and Electronic Component Manufacturers' Federation and it is organized by Industrial Exhibitions Ltd. The following is a list of the exhibitors at the show.

A.B. Electronic Components
A.B. Engineering
AEG (G.B.)
A.E.I. Semiconductors
AMP
APT Electronics
Acbars
Accumulatorenfabrik Sonnenschein
Adams & Westlake
Advance
Albol
Alkaline Batteries
Alma Components
Alston Capacitors
Amphenol
Analog Devices
Antiference
Appliance Components
Ardente
Ariel
Associated Automation
Aston
Audax
Avel-Lindberg
Aviquipo

B.D.O.
BICC
B & R Relays
B.S.I.
BSR
Bailey Stamp
Bakelite Xylonite
J. Beam
Beckman
Belling & Lee
Benedict & Jager
Berec
BICC-Burndy
Biccotest
Birch-Stolec
Bird Electronic
Blessing Electronics
Bobifil Talleres Tarraso
Bonnella
Bourns (Trimpot)
Bradley
Brandauer
Brandenburg
Breeze
Britimpex
British Central Electrical
British Physical Laboratories
Bulgin
Burgess
Burr-Brown

C.C.L.
C.G.S.
Cambion
Cannon
Carr Fastener
Cathodeon Crystals
Celdis
Channel Electric Equipment
Cherry
Clare, C. P.
Coil Winding Equipment
Colvern
Computing Techniques
Concordia
Connollys
Control Data Corp.
Cornish Sign
Counting Instruments
Coutant Electronics
Critchley
Crouzet
Culton

D.A.T. Engineering
Danbridge
Darby Industries
Data Precision
Davall, S.
Davu
Deac
Dial
Diamond H Controls
Doduco
Dubilier

East Grinstead Electronic Components
Edicron
Edison
Efco-Composants
Egen Electric
Elcometer
Electrical Remote Control
Electrographic Peripherals
Electroplan
Electrothermal
Electroustic
Elektromodul
Elektronungtechnika
Elettronica
English Electric Valve
Enthoven
Equipment & Services
ERG
Erie
Erma
Euro
Evans
Ever Ready
Evershed & Vignoles
Electronic Visuals

FR Electronics
F.W. Components
F.W.O. Bauch
Fairchild
Ferranti

GDS (Sales)
GEC Electronic Tube
G. E. Electronics
Gardners Transformers
General Instrument
Globe Union
Goldring
Goodacre & Davenport
Gordos
Gore
Gould
Greenpar
Gresham Lion
Grimes
Guest
Guildline

H.C.D. Research
Hallam Sleigh & Cheston
Hamlin
Harwin
Hatfield
Hayden Laboratories
Haydon
Hellermann
Hesto
Heyco
Hi-G D'Italia
Highland Electronics
Hinchley
Hirschmann
Hirst
Honeywell
Huber, J. J.
Hutson
Hysol Sterling

IDM Electronics
I.M.O. Precision Controls
Imhof-Bedco
Imperial Metal Industries
Insuloid
Integrated Photomatrix
Interelectric

Jackson
Jahre, Richard
Jermyn
Jones, W. (Engineering)

Kabel-und Metallwerke
Kay Metzeler
Keithley
Kenetic Technology
Kent Insulations
King, J. MacA.
Klippon
Kolectric
Krupp, Fried

Lan-Electronics
L.C.R.
Lemosa
Lenco
Levell
Licon
Lipa & Isostar
Littelfuse
Littex
Livingston Hire
Lloyd, J. J.
Lock, A. M.
Londex
London Telephones
Lorlin
Lucas
Lyons, Claude

M-O Valve Co.
McMurdo
Magnetfabrik
Magnetic Devices
Marconi Communication Systems
Marconi Instruments
Markovits
Mashpriborintorg
May Precision Components
M.C.B.
Mecanorma
Membrain
Memory Devices
Metway
Micronel
Miles-Platts
Milton Ross
Monsanto
Morganite
Motorola
Mullard
Multicore

N.S.F.
Newport Instruments
Nombrex
Nulectrohms

Oest Electronic Connecteurs
Oliver Pell
Oltronix
Ostby & Barton

PTA
Pandect
Parmeko
Parsonage
Pedoka
Penny & Giles
Perdix
Perivale Controls
Permanoid
Piher
Pistor & Kronert
Plasmoulds
Plastronics
Plessey
Portescap
Precious Metal Depositors
Pressac
Pye

Quickdraw

R.K.B.
R.M.T.
R. S. Components
Radiatron
Radio Controle /Monopole
Rathdown
Raytheon
Reading Windings
Record
Redpoint
Research Instruments
Resistances
Reynolds
Riam
Rilton
Rosenthal China
Ross Courtney
Ruf. Wilhelm

S.S. Semiconducteurs
Saft
Sakae Tsushin Kogyo
Salford
Satchwell-Sunvic
Scientific Packaging
Scopex
Sealectro
Seddon & Bramhall
Sellotape
Semicomps
Semiconductor Specialists
Sfernice
Siemens
Siemens (Relay Division)
Sifam
Silec
Smiths Industries
Solderstat
Souriau Lectropon
South London Electrical
Southern Transformer
Spear
Special Products Distributors
Spectrol Reliance
Spinner
Sprague
Standard Pneumatic Motor
Steatite
Straumann. Reinhard
Suhner
Surrey Steel Comps.
Switchcraft
Symonds
Systron-Donner

TDK
Tape Recorder Spares
Techna
Techni
Tekdata
Telcon
Telford
Texcan
Thomson-CSF
Thorn
Thousand and One Lamps
3M
Toko
Tokyo Sokki Kenkyujo
Tracor
Transrak
Trident

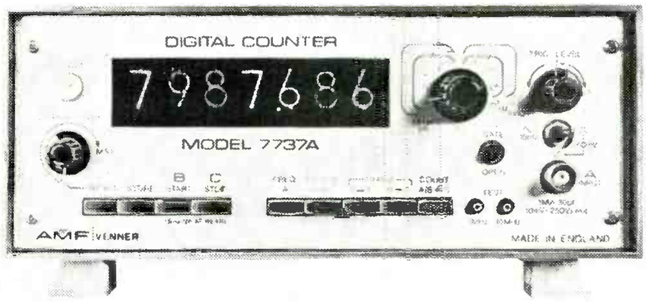
Ultra
Union Carbide

V.T.M.
Venner
Vero
Vitramon

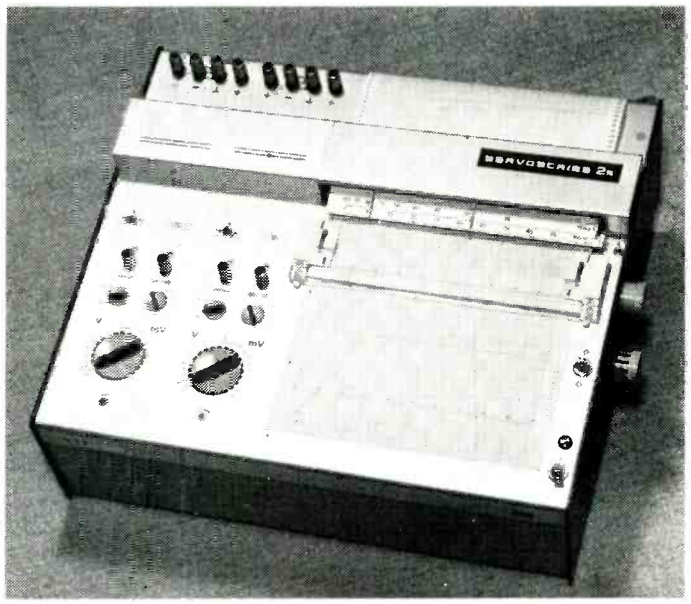
Wallis
Watsons Anodising
Waycom
Wayne Kerr
Weller
Welwyn
West Hyde Developments
Weyrad
Whiteley
Wilson

Xincom

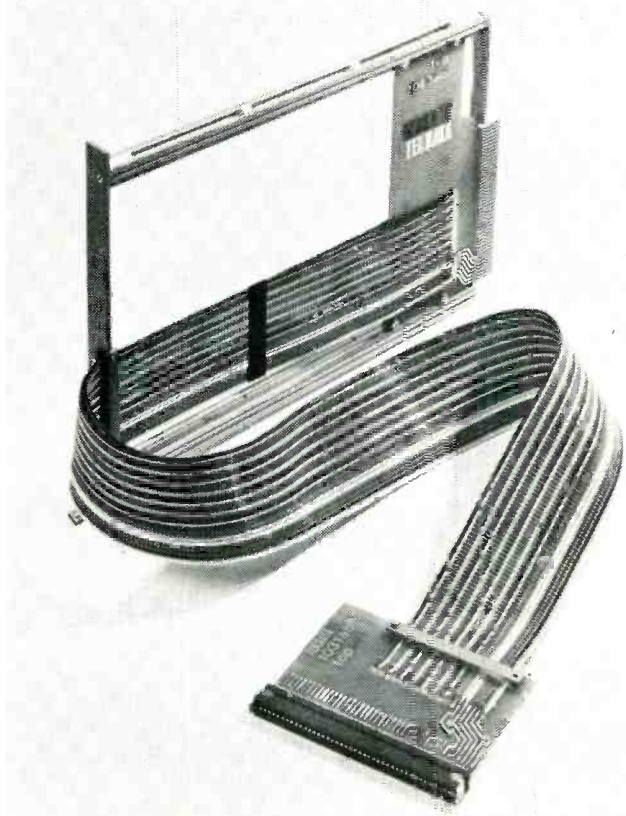
Z & I Aero Services



Digital counter model 7737A manufactured by AMF Venner. This is a seven-digit counter/timer suitable for frequency measurements up to 100MHz.



New Servoscribe 2s flat-bed recorder to be shown by Smiths Industries. This is available in in, in/log, lin plus integrator and in/log plus integrator forms.



Tekdata p.v.c. flat ribbon cable which uses standard insulated wires specified by the customer. The wires are held in a woven polyester mesh.

Traffic Information Broadcasting

Proposals for a European system

One authority has claimed that the density of road vehicles in Britain is 62.2 vehicles per mile giving approximately 85ft of road for each car. Clearly, it is becoming increasingly important for better sources of information to be made available to the driver to enable him to plan and make his journey efficiently with maximum safety. Electronics is playing an increasing part in providing this information and this article is an initial examination of systems of traffic information and hazards warning for road vehicles, based on broadcast announcements

Most of us have experienced the frustration of being the driver of a car stuck in a traffic jam and some of us, the horror of a serious road accident. Solutions to these problems seem a long way off and any improvements which alleviate the situation are clearly welcome. Developments are now in progress which could result in such an improvement in the very near future and since the implications are of importance to communications and electronics engineers we report on the "state of the art" at this moment.

Two concepts

At the moment, the road vehicle is controlled cars, clearly an improvement in decisions not only on his route but also on speed and a host of other considerations. The success of his efforts, measured in terms of safety and good journey time, depend on the quality of the information available to the driver. If we are to continue to accept the idea of driver controlled cars, clearly an improvement in either of the standards can only be brought about by providing better quality information either visually or aurally.

There is a second concept, that of the automatic road vehicle requiring no driver, and here again the system efficiency must be judged by safety factors and journey time. In the case of both, information is vital to success. Traffic engineers believe that information should be viewed at three separate levels, first long range area information which can provide details of slowly changing hazards like snow, ice, road closures and predictable traffic congestion and offer alternative routing information. The second level of information is more local and could provide data on hazards, etc. within say, one hour's drive, together with route diversions to be taken. Finally there is the extremely localized information on accidents, fog patches or other emergencies ahead requiring immediate reaction from the driver. This article looks at important proposals which may help at the first two levels.

The role of the broadcasting station

For some years now, broadcasting stations have been used to provide information in the form of spoken announcements on traffic and weather conditions. In the U.K. this service, although regarded as very valuable, meets only with limited success, first because car radios are fitted to only a small percentage of vehicles and secondly because a nationwide radio service is used to broadcast the information. Local radio is useful, but here again another problem arises — that of the very limited number of v.h.f. car radios in use.

It is quite strongly felt at the B.B.C. that the role of a broadcasting station does not include an extensive traffic information service and, in particular, the cost of co-ordinating and programming such a service should not come from their funds. Needless to say, the capital costs of installation should also be placed elsewhere. However, radio is an established channel of communication at large and car radios are becoming more popular, so it seems logical that there should be some development to provide a better service of announcements to the motorist, preferably without seriously affecting the entertainment value of existing broadcast programmes. Naturally, with our entry into the Common Market, and our strong representation in the European Broadcasting Union, standardization of technique is of great importance, and the E.B.U., through its sub-group K4 of working party K is currently examining three main proposals. Within the E.E.C., working group 30 of the Co-operation Europeanne dans le domaine de la Recherche Scientifique et Technique (C.O.S.T.) and the C.E.P.T. (Committee Europeene, Posts and Telegraphie), sub-group R24 are evaluating the wider spectrum of traffic information systems. The three proposals to these committees originate from the B.B.C., Radio Nederlands, and the German broadcasting authorities in conjunction with their equivalent of the Automobile Association and the electronics company, Blaupunkt.

It would seem that the time for deciding some form of European transmission standard is very close, since considerable activity can be seen in all three camps. Reports have reached this office that the E.B.U. committee is due to sit in a few weeks' time in Spain to discuss the proposals and also that C.O.S.T. Project 30 will be producing a preliminary study report in the summer. From this we can gather that there is no doubt about the future role of the broadcasting station in providing traffic information; it is simply a question now of method.

Radio Nederlands proposal

This proposal arose from an investigation of techniques for broadcasting surround sound and in fact bears interesting similarities with the Dorren quadrophony system described in the A.E.S. Convention report published last month. Essentially it is an extension of the stereophonic pilot tone system where additional low grade audio channels are modulated on to other suppressed single lower-sideband carriers. A maximum of eight channels is provided for, within a band from 64kHz to 100kHz, thus avoiding interference to the existing stereophonic signals which extend to 57kHz.

The carriers are so arranged within 60 to 72kHz and 80 to 100kHz giving a space between 72 and 80kHz to avoid the risk of the fourth harmonic of the 19kHz pilot tone interfering with reception of the traffic information channels. An additional advantage to be gained from this idea is that the band with the 72kHz carrier can be separated using relatively simple filters. The suggested suppressed carriers are at 64, 68, 72, 84, 88, 92, 96 and 100kHz with an additional pilot tone at 57kHz phase locked to the stereo pilot tone and deviating the main carrier by at least 1kHz. This is used to indicate the presence of traffic information on the secondary carriers and presumably would switch a receiver decoder in the car to one of the additional channels.

Experiments made by Radio Nederlands indicate that for an a.f. modulating bandwidth of 200Hz to 3.4kHz, signal-to-noise ratios of 35dB have been obtained, although crosstalk between the additional channels is only 20dB. Perhaps an advantage of this system is that national transmitters can be used to provide regional information using each of the eight channels to give the appropriate data.

It would seem that the proposal by Radio Nederlands has had a somewhat chequered career since it is a revival of an earlier proposition which receded into the background for a period of time. As was pointed out by Professor Geluk of Radio Nederland, when commenting on the Dorren system at the A.E.S. Convention, this type of transmission brings serious protection ratio, and adjacent channel, problems, and it remains to be seen if he

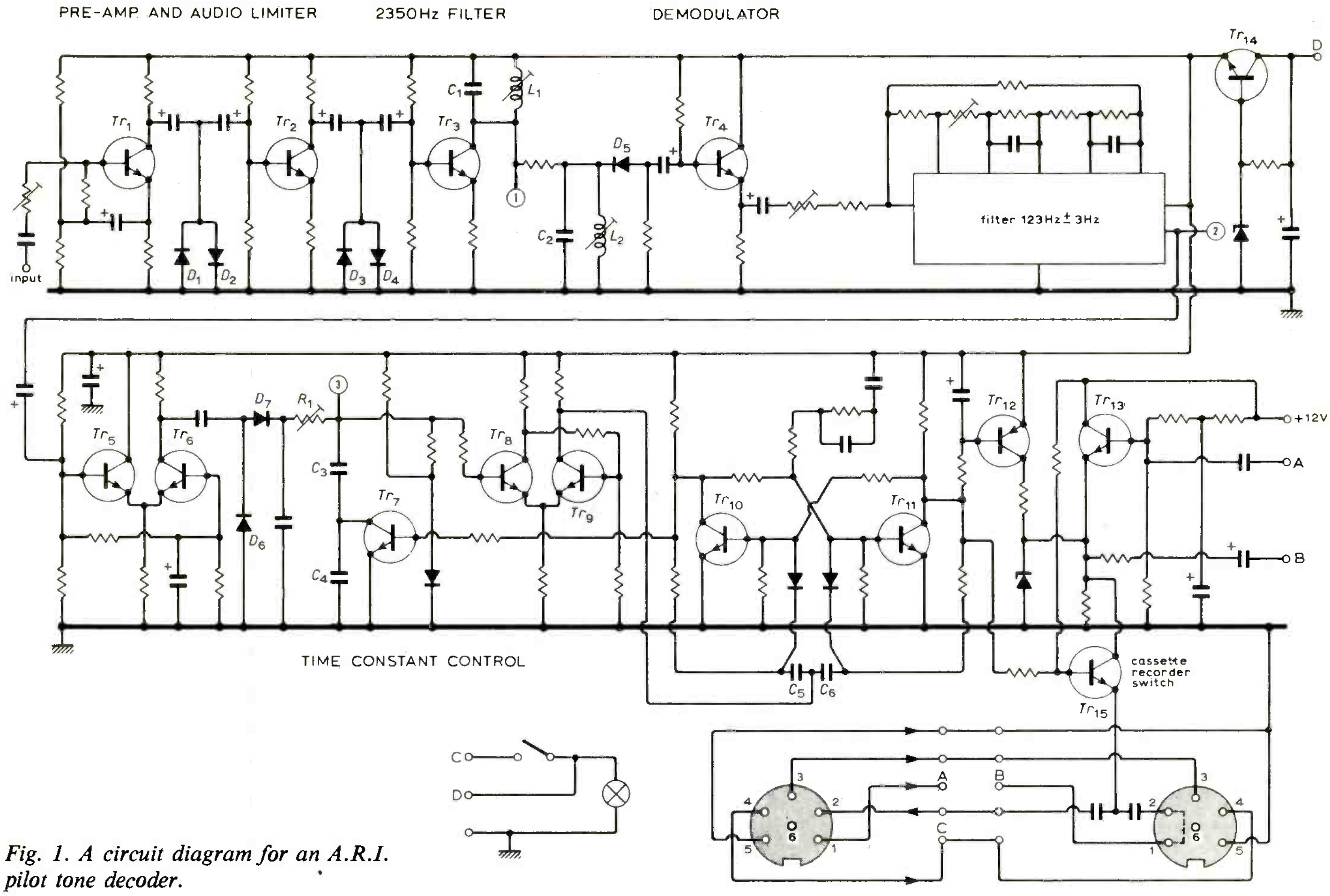


Fig. 1. A circuit diagram for an A.R.I. pilot tone decoder.

has overcome these in this particular instance.

The B.B.C. proposal

The Dutch system just described is, of course, based on the use of v.h.f. transmitters since there is a preponderance of this type of car radio in Europe. In addition, since the Netherlands are largely flat, the particular method of providing regional information is very necessary since v.h.f. and m.f. propagation is very good, thus barring the use of regional transmitters. In the U.K., however, car radios are largely m.f. and l.w., and v.h.f. programmes, apart from the small local radio stations, are a national network with unpredictable (for these purposes) propagation. The B.B.C. proposals are therefore based upon utilizing the m.f. band with amplitude modulation and the use of a separate, inexpensive, receiver in the vehicle. In addition there is a greater degree of concentration upon local information in a radius of 30km about a transmitter. The suggestion is made that a complete national network of low power m.f. transmitters could be designed to operate on a single frequency in the range immediately below 525kHz. Some provision has to be made, of course, to prevent simultaneous transmission of stations within a range likely to cause interference and this could be achieved by some system of time division multiplex.

The size and distribution of appropriate service areas could be determined by the appropriate traffic or police authorities. If a reasonably complete coverage is to be achieved, the transmitters need to be arranged in the form of a lattice having a spacing of about 50km and the B.B.C. Research Department has investigated two theoretical lattices for the U.K., one containing nine transmitters in a group and the other 16 in a group. Minimum interference distances are said to be 120km and 170km respectively. Since only one transmitter in the group is to operate at any one moment, the announcement duration allocated to each station in a group of nine is one ninth of a complete cycle or one minute in nine.

The B.B.C., in their E.B.U. proposals to be published shortly, suggest that the receiver could be a simple straight design, probably of greater simplicity than the conventional transistor type currently available. With no wavechange or tuning control necessary, the suggestion is made that total retail cost would approximately be £5 to £7 excluding the aerial. Adjustment of receiver muting is clearly critical since if it is too low interference from distant stations could occur in some instances and if too high some local information could be lost.

A further suggestion, interesting in its implications, for one of the German proposals is that if an exclusive m.f. channel could not be allocated for traffic information, interference from "non-traffic" stations could reduce service at night and thus the inclusion of an audio switching signal at the start of each transmission could be used to operate a receiver audio switching device.

The B.B.C. proposal goes on to suggest techniques for operating this system, but since the system design is so designed on a regional basis, but with potential national control, we leave the reader to draw his own conclusions on how best this could be done. Needless to say, the B.B.C. has offered several different methods to meet a variety of needs. It should be made clear that this is as yet only a theoretical study with no experimental work completed to establish its viability.

The German proposals

Of the three systems, the German is probably the most advanced, since practical experiments involving broadcasting stations and ordinary motorists have been under way since 1970. Two basic techniques have been evolved, first for the m.f. network based on "Deutschlandfunk" and secondly the later introduction of a more comprehensive system for v.h.f. based on the well developed network of local stations. It would seem that the motivation for the development of both systems came from the A.D.A.C., which is the German equivalent of our Automobile Association who wished to make more complete information available to the motorist.

The m.f. system, called A.-R.I. (Auto-Radio Information) starts with an hourly traffic announcement preceded by a readily recognized signature tune that starts and ends with a pilot tone. At motorway service stations, unattended information desks are provided which contain equipment tuned to Deutschlandfunk, and on receipt of the pilot tone this switches on a recorder which stores the broadcast message.

In a similar fashion, the recorder is turned off by a similar pilot tone included in the terminal melody broadcast by the transmitting station. The pilot tone consists of a start signal of 2.35kHz frequency modulated by 123Hz and with a period of one second, and the same tone is used with an 0.5s duration to terminate the recording activity. Motorists can retrieve the message by pressing a button on a telephone receiver mounted on the desk and thus update on the latest situation.

The same pilot tone can be used to switch an automatic mute in a car radio, and to activate a car-borne cassette recorder if necessary. A third application is to be found in the home where a radio receiver and cassette recorder are switched by a time clock to record all announcements made for a predetermined period before the journey starts. Adapting the m.f. system to include regional station selection, a receiver has been designed to search the m.f. band every 10 seconds for the strongest signal and, on locating it, to re-tune the receiver to that station, thus avoiding the problem of the driver having to re-tune manually and lose driving concentration.

The development of this m.f. system into v.h.f. has been made possible by the well established network of v.h.f. regional stations, most of which already broadcast stereo. The traffic programme introduction is the same as for m.f. and thus muting switches can be used. However, the advent of electronic varicap tuning has made it possible to extend facilities still further. Each station broadcasting traffic information is identified by the presence of a 57kHz pilot tone, which is obtained by tripling the 19kHz stereo pilot and is therefore rigidly locked to it in frequency and phase. In this instance a v.h.f. set is fitted with an external decoder which plugs into the tape recorder jack of the radio. As the appropriate station is tuned in, a lamp lights on the decoder, indicating that a "traffic information station" has been selected. However, manual tuning and the need to look for the lamp reduces the attention of the driver and so a push button is included which mutes the audio output of all stations not transmitting 57kHz. The moment audio appears the driver knows he is tuned to an information station. As signal strength declines the muting operates and re-tuning is thus obviously necessary. Using the A.-R.I. decoder as well, the radio volume control can be set to zero, and when the A.-R.I. pilot tone is received the audio stage of the receiver will be switched on to a preset level during the traffic announcement.

Automatic tuning does of course help to automate many of the manual operations described and using the v.h.f. pilot decoder one receiver in production will search for traffic information stations only, and then re-tune when signal strengths get too low. Alternatively in another radio set any station can be selected for its entertainment value and a second integral "station finder" within the set meanwhile constantly searches for and tunes to strong traffic information stations. When the A.-R.I. pilot is transmitted the initial programme selection is muted and the announcement switched to the audio output. On receipt of the terminal tone, the receiver reverts to the original programme selection.

Blaupunkt, who have been largely responsible for the system development, say that the decoders cost around £5 to £7 each and can be fitted to any radio with a tape recorder jack corresponding to the D.I.N. specification referring to car radios.

An extension to the v.h.f. system is proposed where the 57kHz pilot is itself modulated with an l.f. tone in the range 20 to 80Hz. Each region has its own identifying tone, thus making it possible to programme the electronic tuning of car radios to be even more selective in tuning to strong traffic stations. The driver can preselect the region he wants to listen to, even though freak reception of a distant v.h.f. transmitter may have caused the decoder to "lock-on".

The circuitry of one of the A.-R.I. decoders is shown (Fig. 1). When the decoder is switched off the +12V supply is connected to Tr_{13} only, and with this device conducting audio is fed from input "A" through Tr_{13} to point "B". When the decoder is switched on, +12V is fed via Tr_{14} to all stages of the decoder and the cassette recorder if fitted. Since Tr_{13}, in this condition is non-conducting, the audio is muted. On receipt of the 2.35kHz frequency modulated 123Hz tone indicating "start", Tr_1 and Tr_2 amplify the signal and D_1, D_2 act as limiters. Components C_1, L_1 are tuned to 2.35kHz; C_2, L_2 act as a slope detector for the 123Hz. This signal is fed via Tr_4 to an active filter based on the TAA960. From that point the signal feeds a threshold biased differential amplifier Tr_5, Tr_6 followed by the voltage doubling combination and rectifier network D_6, D_7. Capacitor C_3 charges via R_1 and after about 0.7s sufficient voltage has been developed to switch the Schmitt trigger Tr_8, Tr_9. After one second, the tone finishes and the state of the trigger reverts creating a negative going pulse which is applied to C_5, C_6. This pulse trips the bistable pair Tr_{10}, Tr_{11} to turn on Tr_{10}, and through Tr_{11} and Tr_{12}, to turn on Tr_{13} which now passes the audio signal to the output stage of the receiver.

Since Tr_{10} is now conducting, the base voltage of Tr_7 will be zero and hence C_3, C_4 will be series connected to reduce the time constant, thus programming the decoder for the 0.5s duration "stop" pilot tone.

This system is in experimental operation nationally in Germany and the decoders and car radios are currently commercially available.

European standards

As mentioned earlier, European governments and the E.E.C. believe that for any system of broadcast traffic information to work successfully some common standard must be agreed upon. To this end, the two committees of the E.B.U. and E.E.C. working parties have established some guidelines. For example, unconfirmed reports indicate that the C.O.S.T. working party has suggested the following principles to be used.

First, any proposal should be capable of being put into operation within five years. Secondly the capital investment should be no more than about £1.2 million to £1.5 million. The system to be adopted and called by the working party the "Mark I" will probably represent the first of a generation of more complex or comprehensive systems which will include highly localized information. Such systems are called "road based" and include inductive loops buried in the road (not found very practicable by the U.K. Road Research Laboratory), leaky coaxial lines or even very low power r.f. transmitters covering about 1 mile sections of a motorway.

In addition, there are other considerations; normal programmes ideally should suffer minimum interference and special receiving equipment should be of the lowest cost and available to all. A final regulation is that the patent licence for the system is freely available to all, thus avoiding the possibility of a monopolistic situation arising.

A superficial examination of these requirements together with the more technical limitations placed by restricted availability of frequency allocations within m.f. band, seem to weigh the scales in favour of the German system. Apart from the fact that it is the only working system and is well developed, it also is less likely to cause adjacent channel interference than the Dutch proposals. A final point is that the transmitter modifications are limited and inexpensive.

The alternative m.f. pilot "melody" offers compatibility with British requirements and could be adopted by all stations without problems. The only real difficulty lies in the wide coverage of normal broadcast stations and one can easily see difficulties in Holland and the U.K. where comparatively few transmitters serve the whole country. The B.B.C. proposal is obviously an answer to this but does leave open the question of the capital cost of the 93 transmitters required for coverage.

The Dutch proposal is definitely the most complex and can probably be regarded as an "also-ran" since the transmitter equipment is complex and still to be developed.

It is interesting however to see how each proposal has resulted from very national requirements, and it now remains to be seen how effective the various lobbying attempts are. Here in the U.K. the I.B.A. are known to favour the m.f. pilot "melody" system which, of course, suits their requirements.

This summer may see a rationalization of broadcasting systems for traffic information and the first step towards improving the "driver's lot" since traffic programmes were initiated.

Experiments with operational amplifiers

9. Multivibrators: free-running, monostable and bistable circuits

*by G. B. Clayton,** *B.Sc., F.Inst.P.*

Operational amplifiers are normally used in negative feedback circuits but when appropriate positive feedback connections are made to them they can be used to generate both sinusoidal and non-sinusoidal waveforms of defined frequency. In this section we investigate the way in which positive feedback may be applied to an operational amplifier in order to give a multivibrator type of circuit.

A circuit suitable for investigating the behaviour of a simple free-running multivibrator is illustrated in Fig. 9.1. Positive feedback is applied to the amplifier by the connection between the output terminal and non-phase-inverting input terminal via the divider R_2, R_1. The divider gives a positive feedback fraction

$$\beta = \frac{R_1}{R_1+R_2}$$

The amplifier switches regeneratively and repetitively between saturated states, remaining in alternate states for time periods governed by capacitor charging. The amplifier remains in positive saturation for a time period

$$t_1 = CR\log_e \frac{V^+_{o\,sat} - \beta V^-_{o\,sat}}{V^+_{o\,sat} - \beta V^+_{o\,sat}} \qquad (9.1)$$

and in negative saturation for a period

$$t_2 = CR\log_e \frac{V^-_{o\,sat} - \beta V^+_{o\,sat}}{V^-_{o\,sat} - \beta V^-_{o\,sat}} \qquad (9.2)$$

If the positive and negative output saturation limits have the same magnitude the two timing periods are equal and the waveforms produced are symmetrical.

It is suggested that the action of the circuit and the validity of eqns. 9.1 and 9.2 be investigated by observing and recording the waveforms at terminals 6, 3, and 2. Quantitative measurements should be made with the positive and negative swings and time periods of all waveforms recorded.

Typical waveforms for the circuit are illustrated in Fig. 9.2. The upper trace shows the amplifier output voltage as it switches between positive and negative saturation limits. The middle trace shows the signal at the non-phase-inverting input terminal switching between the limits $\beta V^+_{o\,sat}$ and $\beta V^-_{o\,sat}$, and the lower trace shows the exponential charging at the phase-inverting

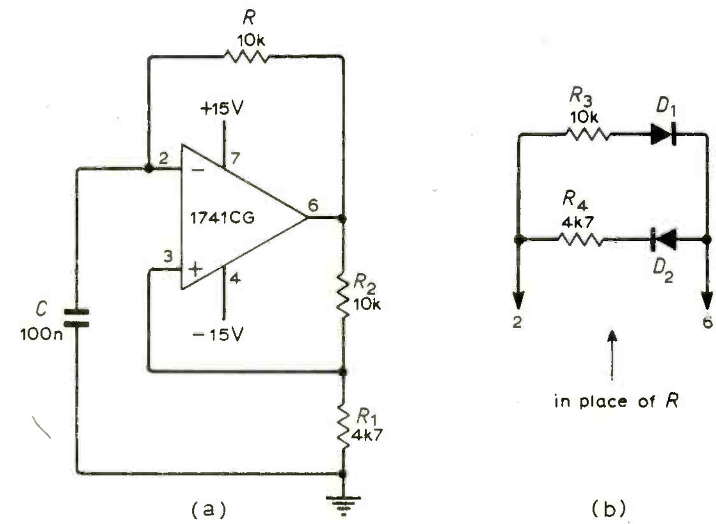


Fig. 9.1(a). Free-running multivibrator; (b) alternative timing resistors.

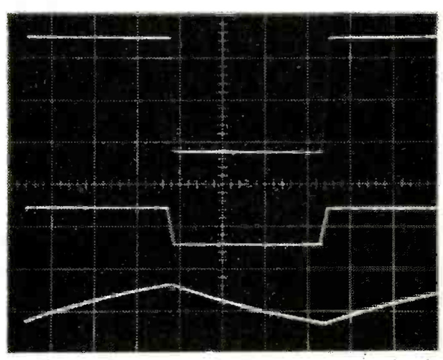


Fig. 9.2. Free-running multivibrator waveforms: upper trace, pin 6; middle trace, pin 3; lower trace, pin 2. Vertical scale, 10V/div.; horizontal scale, 0.2ms/div.

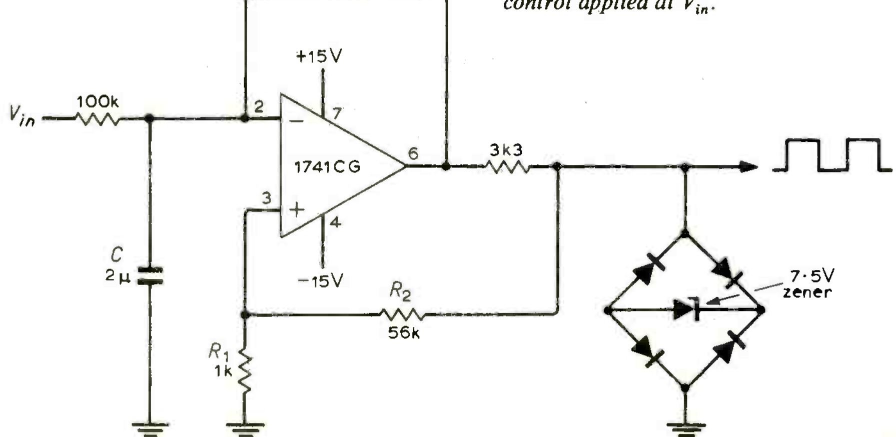


Fig. 9.3. Multivibrator with pulse width control applied at V_{in}.

*Department of Physics, Liverpool Polytechnic.

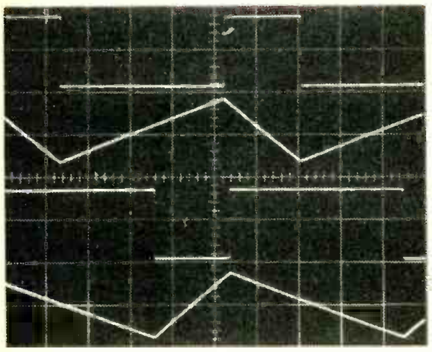


Fig. 9.4. Waveforms for free-running multivibrator (Fig. 9.3) with pulse width control. Traces show output voltage (10V/div.) and voltage at pin 2 (0.2V/div.) for V_{in} of +5V and −5V respectively. Horizontal scale, 2ms/div.

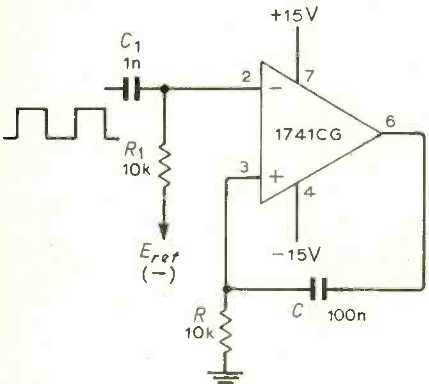


Fig. 9.5. Monostable multivibrator with timing period controlled by a reference voltage.

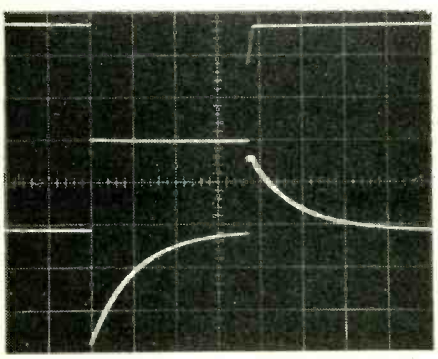


Fig. 9.6. Monostable waveforms for reference voltage −0.5V. Upper trace, pin 6; lower trace, pin 3. Vertical scale, 10V/div.; horizontal scale, 1ms/div.

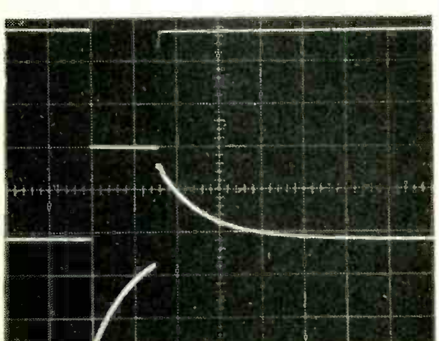


Fig. 9.7. Monostable waveforms for reference voltage −5V. Upper trace, pin 6; lower trace, pin 3. Vertical scale 10V/div.; horizontal scale, 1ms/div.

input terminal. The exponential goes up and down between the limits $\beta V^+_{o\,sat}$ and $\beta V^-_{o\,sat}$.

Components values should be substituted in eqns. 9.1 and 9.2 in order to compare predicted timing periods with those obtained experimentally. Further understanding of circuit action may be gained by changing component values and by making separate changes in the values of the positive and negative power supplies. The effect on the waveforms of each change should be noted and recorded, and the reader should then attempt to explain for himself these effects in terms of the action of the circuit.

A markedly non-symmetrical waveform can be obtained by using alternative timing resistors (R_3 and R_4) switched into the circuit by means of the diodes D_1 and D_2 as shown in Fig. 9.1(b). Resistor R in (a) should be replaced by this network and the observed waveforms recorded and explained. Note that the upper frequency limit for the action of the multivibrator circuit is set by amplifier slewing rate. This point should be verified.

Control of the pulse width produced by a free running multivibrator can be obtained by injecting an additional current into the phase inverting input terminal of the amplifier. The effect of this current is to increase one timing period and decrease the other. The action may be investigated using the circuit illustrated in Fig. 9.3.

The circuit includes a method for symmetrically clamping the output voltage limits of the amplifier by means of a diode bridge and zener diode. The clamp is not essential to the action of the circuit but is included to illustrate a method of output limiting. Output limiting may be applied to any of the switching circuits described in this section if the application requires it.

Waveforms obtained with the circuit of Fig. 9.3 are shown in Fig. 9.4. The traces show output voltage and voltage at pin 2 for V_{in} of +5V and −5V respectively. Pulse width is not linearly related to the input voltage because capacitor C charges exponentially. Linearity can be improved by reducing the amplitude of the waveform at pin 2 (by reducing R_1).

The circuit for a monostable multivibrator with timing period controlled by the magnitude of a reference voltage is given in Fig. 9.5. The permanently stable state for this circuit is with the amplifier output at its positive saturation limit, this condition being maintained by the negative reference voltage applied to the phase inverting input terminal of the amplifier. A positive triggering voltage applied to the phase inverting input terminal, of sufficient magnitude to bring the amplifier out of saturation, causes the circuit to switch regeneratively to its temporarily stable state. The circuit returns to its permanently stable state when the voltage at the non-phase-inverting terminal, which switches below earth by an amount $(V^+_{o\,sat} - V^-_{o\,sat})$, exponentially rises to the reference voltage level. The timing period for the circuit is given by the equation

$$T = CR \log_e \frac{V^+_{o\,sat} - V^-_{o\,sat}}{E_{ref}} \qquad (9.3)$$

The action of the circuit may be investigated by applying a square wave of level, say, 6V and frequency approximately 200Hz to the phase inverting input terminal via capacitor C_1. The square wave is differentiated by C_1R_1 and the positive pulses cause the monostable to make transitions. The waveforms appearing at pins 6 and 3 should be observed and recorded for different values of the reference voltage in the range −0.5V to −5V. Typical waveforms for reference voltages −0.5V and −5V are shown in Figs. 9.6 and 9.7 respectively.

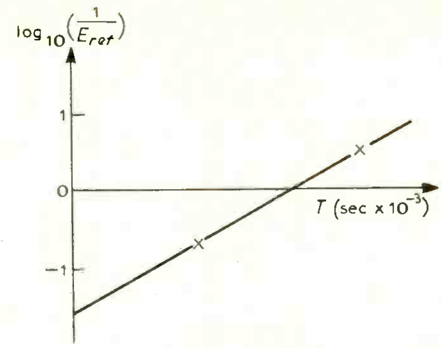


Fig. 9.8. Plot of $\log_{10}(1/E_{ref})$ against T.

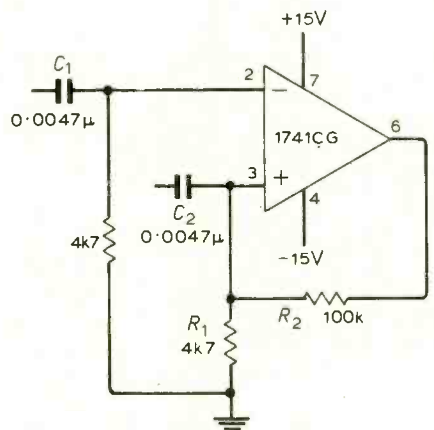


Fig. 9.9. Bistable multivibrator. Triggering may be applied at C_1 or C_2.

The validity of eqn. 9.3 is most conveniently checked by presenting the results graphically as shown in Fig. 9.8. By expressing logarithms to the base 10 and rearranging eqn. 9.3, the equation may be written

$$\log_{10}\frac{1}{E_{ref}} = \frac{T}{2.3CR} - \log(V^+_{o\,sat} - V^-_{o\,sat})$$

The graph in Fig. 9.8 should thus have a slope of value $1/(2.3CR)$ and make an intercept on the vertical axis at a value equal to $-\log_{10}(V^+_{o\,sat} - V^-_{o\,sat})$.

A circuit which uses an operational amplifier as a bistable multivibrator is shown in Fig. 9.9. Positive feedback applied via resistors R_2, R_1 causes the amplifier output to remain at either its positive or negative saturation limit.

Triggering pulses may be applied to the circuit at either input terminal via the capacitors C_1, C_2. The pulse polarity required to produce a transition depends upon the state of the circuit; this point should be verified experimentally.

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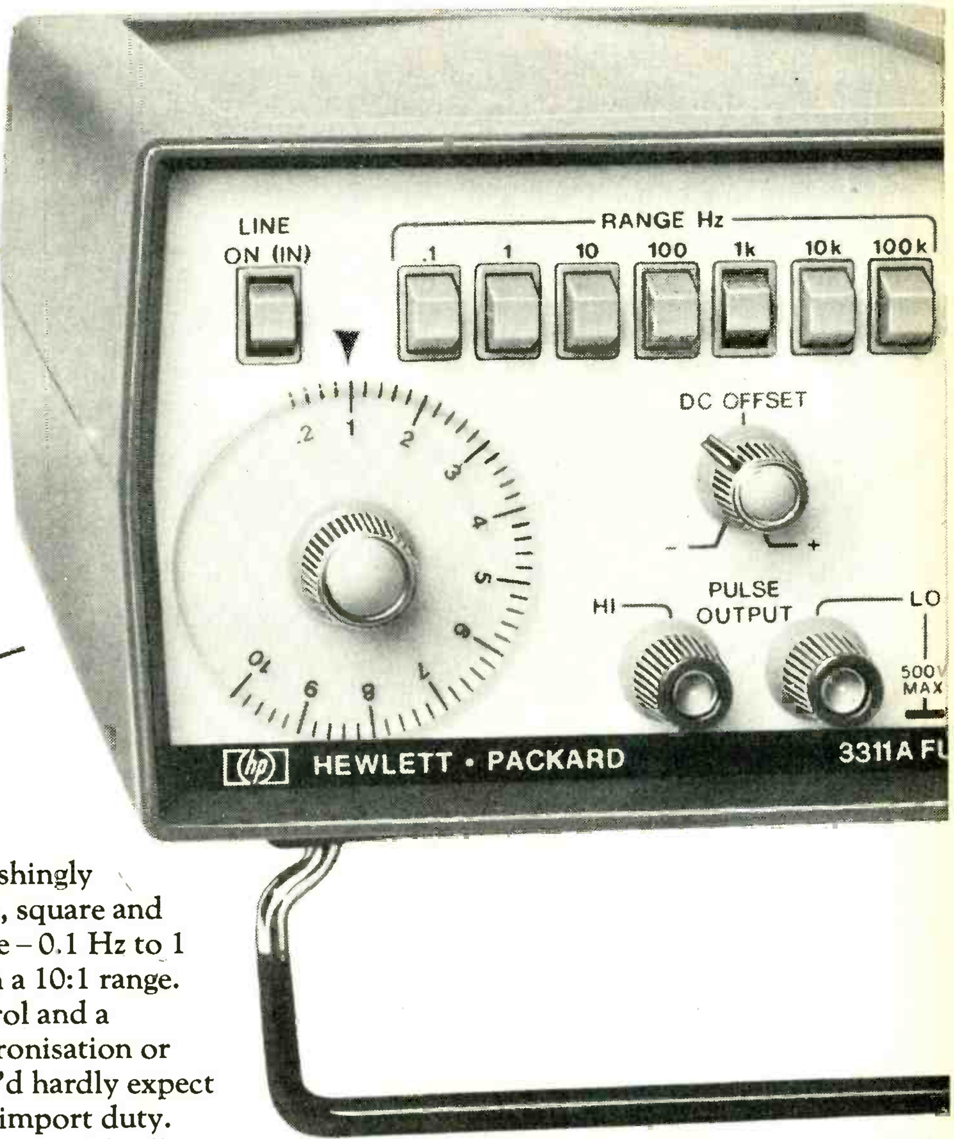

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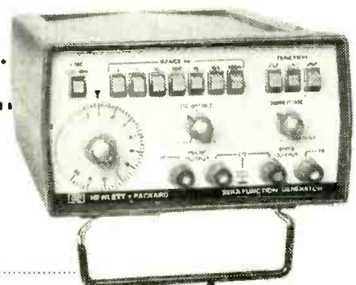

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A Novel Approach to Power Supply Design

by Robin Aston*

A power supply design technique is discussed which employs a switching regulator to achieve low weight, followed by a linear regulator to give laboratory standard performance. A feedback loop from the output of the linear regulator controls the mark-space ratio of the inverter signal in the switching regulator and so minimizes the power dissipated by the series control element of the linear regulator.

The problems encountered when trying to obtain a stabilized d.c. voltage from an a.c. mains supply have always been of interest to circuit designers. In the days of the valve the problems were not perhaps so acute as they are today, the d.c. current requirements usually being quite modest. Modern semiconductors are capable of controlling very large currents and it is now the norm to think in terms of power supplies of several amps rather than the few tens of milliamps of the early days.

Modern power supplies can be divided into three basic families: series linear, shunt linear and switching. These will be discussed in turn.

*APT Electronics Ltd.

Series linear regulators

Whenever the highest possible performance is required the series linear regulator is the usual choice. Even if a lower performance is needed the flexibility of the series linear regulator, and the huge quantity of design information available, make it the most widely used form of power supply. The basic block diagram is given in Fig. 1.

The output voltage is compared with a precision voltage reference. If the two differ, the comparator either increases or decreases the impedance of the series control element to correct the output voltage. To allow the series control element to do its job, the unregulated d.c. from the transformer and rectifier must always be of a higher voltage than the required output voltage.

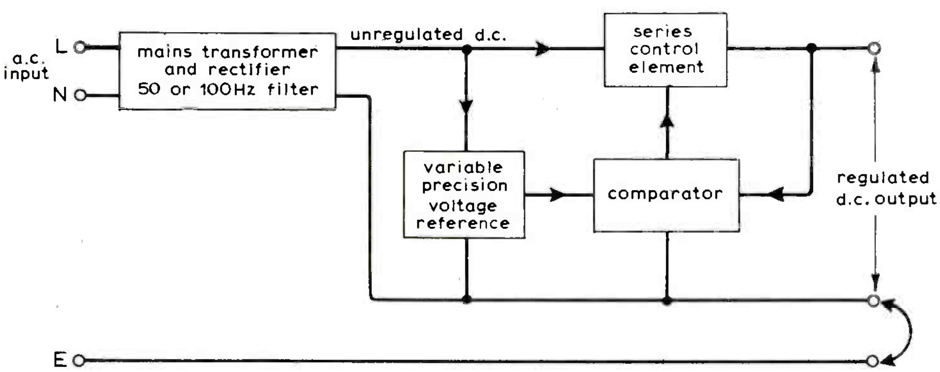


Fig. 1. Series regulator block diagram.

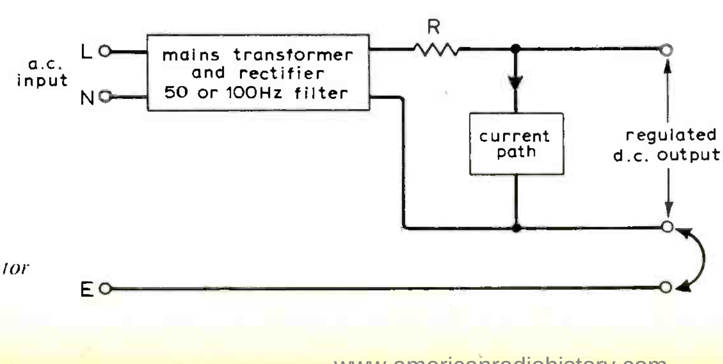


Fig. 2. Shunt regulator block diagram.

For the purposes of comparison we shall imagine that all the power supplies discussed in this article have an output variable from 0 to 50V at 10A. In Fig. 1 the unregulated d.c. supply must be greater than 50V, let us say 55V. At 1V, 10A output, 54V would be dropped across the series control element and 540W would therefore need to be dissipated by it. This problem is usually overcome by having a range switch. This would vary the output of the unregulated supply so that the power dissipated by the series control element could be limited to a reasonable value.

The basic regulator described would normally have all sorts of frills built in such as constant current, current limit or re-entrant short-circuit protection, and over-voltage protection.

Shunt linear regulators

This form of regulator has never achieved the same wide use as the series regulator, probably because it is not well suited to applications where the output current will vary over a wide range. The basic idea can be seen in Fig. 2. The current path is sensitive to the voltage on the output terminals. If the output voltage tends to rise, the impedance of the current path is made to fall and more current flows in it, reducing the output voltage by increasing the voltage drop across *R*. A voltage reference and voltage comparator similar to that used in the series regulator might be employed to control the current path. The simplest form of shunt regulator is, of course, the zener diode.

Taking the case of the 50V, 10A supply; at 50V, 1A output, the current path would have to dissipate the additional 9A at 50V (450W) and a further 50W would be dissipated by *R*. Essentially the circuit has a see-saw action. A constant 10A flows through *R* which is shared by the current path and the load.

Switching regulators

The main disadvantages of the series and shunt approaches are, the need to dissipate large amounts of power by the control element (although our examples are at the extreme) and the sheer size and weight of the mains transformer with the associated bulky 50Hz smoothing components.

The switching regulator overcomes these problems but, at the same time, introduces

TABLE 1

	Linear	Switching	Linear/switching
Regulation	excellent	good	good
Transient response	excellent	poor	fair
Ripple and noise	excellent	poor	good
Voltage adjustment	fairly easy	fairly difficult	easy
Size	large	very small	small
Weight	heavy (90 lb)	light (10 lb)	light (16 lb)

some new difficulties. A block diagram of a typical switching regulator is shown in Fig. 3. A high-frequency oscillator, usually operating just above the a.f. range, is powered from a mains supply and rectifier. The oscillator operates in a switching mode with two transistors switching hard-on and hard-off in turn, alternating the current flow in the primary winding of an h.f. transformer which is followed by a rectifier and filter. The regulator output voltage is measured by the oscillator control module and a correction signal is produced which varies the mark-space ratio of the oscillator. If the output of the power supply tends to fall, the duty cycle of the oscillator is increased, which raises the average value of the power in both primary and secondary windings and, consequently, the rectified output voltage remains constant.

The main advantage of the switching regulator is that the isolating transformer and filter components are operating at high frequency and can be of a very small size as compared with the 50 or 100Hz counterparts. Unfortunately, the transient response is not very good and inevitably broad-band noise from the oscillator finds its way to the output. However, in many applications these shortcomings are of no consequence and the switching regulator can offer many users the answer to their problems.

Switching and linear techniques combined

A number of the disadvantages of both switching and linear regulators can be overcome or minimized by a technique which combines both regulators in a single circuit (Fig. 4).

Operation of the system is best described by imagining that the unit is switched on and is supplying an output, say 40V, to a load. Point A on the circuit must be at a potential of more than 40V for the series control element to function. For reasons which will become clear later it will be stated that this point is at 45V. If the voltage reference source output at point B is deliberately lowered to 30V the comparator will provide an output which will increase the impedance of the series control element, causing the output voltage at point C to be reduced to 30V. As this is taking place, the voltage drop across the series control element will rise. The oscillator control module senses this increase between points A and C and lowers the duty cycle of the oscillator so that the input voltage at point A falls. Circuit values can be such that the voltage across the series element is maintained at 5V and with 30V now at the output, point A will be at 35V.

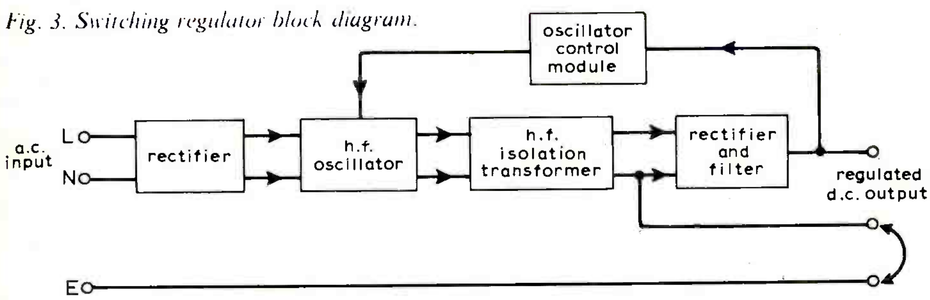
The application of this technique to the 0 to 50V, 10A power supply we are discussing ensures that power dissipation by the series control element is limited to 50W in the worst case condition of 1V output at 10A. In fact, the control element dissipation is now directly proportional to the current drawn from the power supply.

The main advantages of this technique are, therefore, the elimination of the 500W, 50Hz transformer and bulky 100Hz smoothing components, and a considerable reduction in internal power dissipation allowing smaller heat sinks to be used. Such a power supply does not perform as well as a good quality series linear regulator but is much better than a straight switching regulator. For the example of a 50V, 10A power supply, the relative advantages of the linear series, switching, and combined linear-switching regulators are summarized in Table 1.

Functional description

A simplified block diagram of a combined linear/switching power supply appears in Fig. 5. The incoming mains supply is filtered by F_1 to prevent spurious signals from the high-frequency oscillator or inverter from finding their way into the mains wiring and possibly interfering with other equipment. The supply is then divided into two, feeding a small 50Hz transformer T_1 and a high voltage rectifier bridge R_1. The small mains transformer is intended to power the inverter control module for a very short period of time until the system becomes fully operational. The inverter control module provides pulses which switch the inverter output transistors on and off in turn, driving current through the primary of the high-frequency transformer T_2. A secondary winding of T_2 provides a d.c. input at *c-d* on the inverter control module, supplying the module with power and back-biasing the bridge rectifier diodes R_2, effectively turning off the small mains transformer T_1. The output of the high-frequency transformer T_2 is rectified by R_3 and applied to the smoothing filter F_2. The design of this

Fig. 3. Switching regulator block diagram.



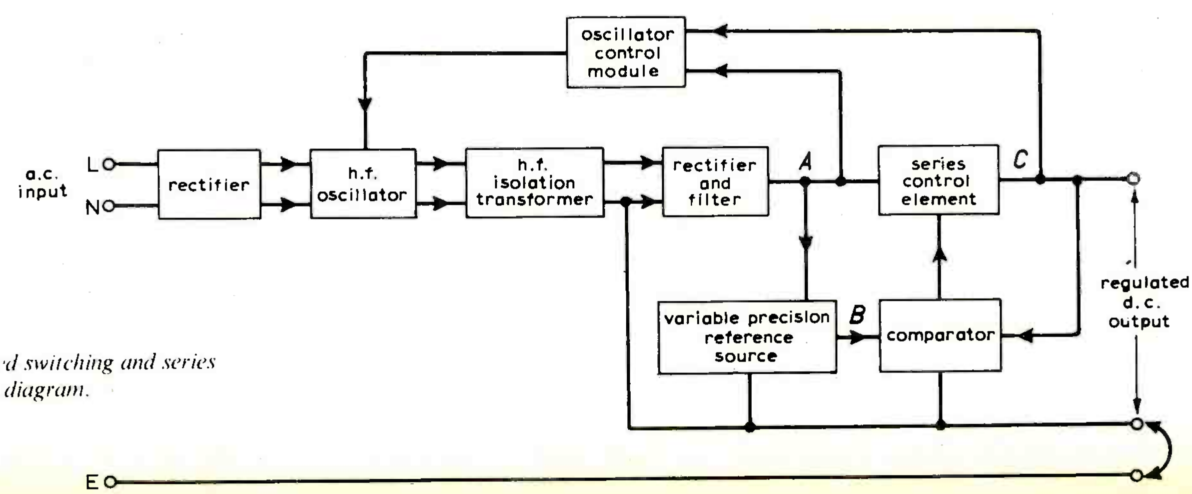


Fig. 4. Combined switching and series regulator block diagram.

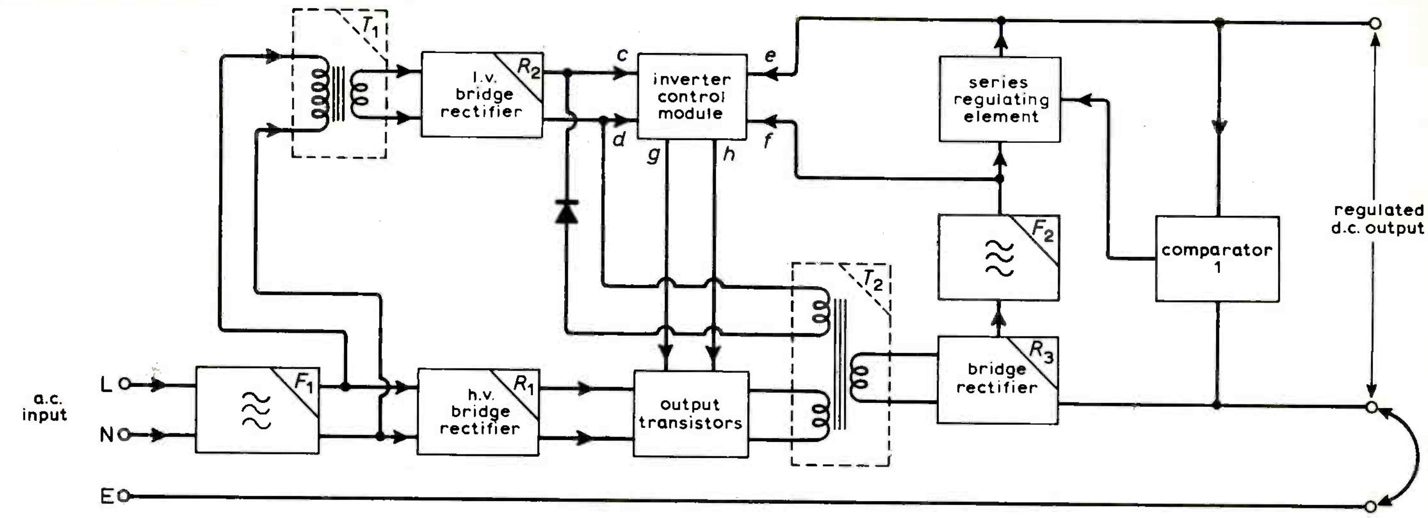


Fig. 5. Block diagram of the combined switching and series regulator.

low-pass filter is such that during the quiescent periods of the inverter, the main energy requirement of the load is supplied from energy stored in the series choke and not the shunt capacitors. Because the capacitors are topped-up by the induced e.m.f. of the choke the average charge, and therefore the voltage across the capacitors, is independent of load current for a given output voltage.

The linear regulator section of the circuit, functions in the normal way except that the voltage drop across the series control transistor is sensed at *e-f* by the inverter control module. This module then varies the duty cycle of the inverter to maintain the voltage drop across the series control element at 5V.

Inverter control module

The inverter control module has to produce switching waveforms at *g* and *h* for the inverter output transistors at a frequency of about 20kHz. The higher the energy demanded from the power supply, the higher the mark-space ratio of the switching waveform.

The circuitry of the inverter module is shown in block diagram form in Fig. 6. Power from the small mains transformer T_1 and rectifier bridge R_2 (Fig. 5) is fed to a small linear voltage regulator which supplies power to the 20kHz generator. The output of this generator is fed to the bases of the inverter output transistors (Fig. 5) under the control of a gate circuit. Also the generator drives a triggered ramp generator producing a sawtooth, synchronized with the inverter which feeds one side of the level detector. The other side of the level detector is fed from a comparator which provides a voltage proportional to the difference between a 5V reference and the voltage across the series stabilizer transistors (*e-f*, Fig. 5). Normally the level detector opens the gate when the output of the comparator is less than the ramp voltage. Whenever the voltage across the series stabilizer transistors falls below 5V, the output of the comparator falls and the level detector opens the gate earlier in the generator's cycle.

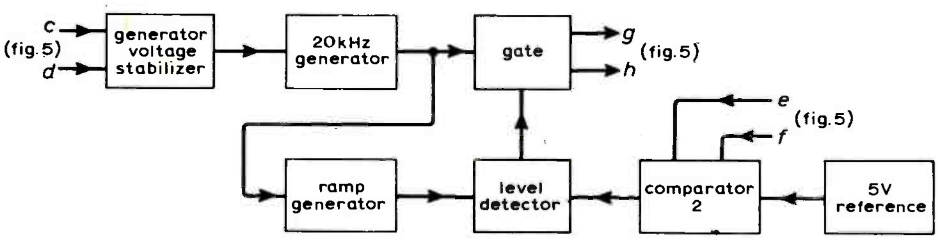


Fig. 6. Block diagram of the inverter control module.

To demonstrate the operation of the inverter control module, it is best to consider the complete combined switching/linear regulator, referring to Figs 5 and 6.

Imagine that the power supply is providing a constant output into a load and that the resistance of the load is suddenly reduced. As the output current rises, the output voltage would tend to fall. The linear section of the power supply compensates by reducing the impedance of the series control element and, as a secondary result, the voltage drop across this element also tends to fall. This trend results in a fall in output of comparator 2 in the inverter control module as the voltage across *e* and *f* tries to fall below the 5V reference. The level detector now opens the gate at a lower ramp voltage and the duty cycle of the inverter output transistors is increased. A greater voltage is fed to the series control transistors, increasing the voltage across *e* and *f*, and the output voltage of the power supply is maintained with a constant 5V developed across the series linear control element.

Additional components in the inverter control module inhibit the gate at switch-on until the inverter stabilizer and the inverter itself settle down, thus preventing possible damage to the inverter output transistors. If the mains input voltage rises above a predetermined level, a mains monitor circuit closes the gate earlier in each cycle to compensate.

The effectiveness of the combined switching/linear power supply can be judged by the performance achieved by a typical unit which is given in Table 2.

TABLE 2

Mains voltage	220V or 240V ±10%. The unit will operate through a continuous range from 198–264V.
Mains frequency	48–450Hz.
Constant voltage characteristics	
Output voltage	0–50V (max.)
Setting accuracy	±10mV
Output current	0–10A (max.)
Line regulation	0.001%+1mV for ±10% mains variation
Load regulation	0.05%+10mV for 10%–100% load variation
Ripple and noise	5mV pk.
Output spike	40mV pk. rep. rate 40kHz (typically 20mV).
Transient response	5ms to recover to within 20mV for a 10–100% load change
Temperature characteristics	
Coefficient	Less than 0.02% per °C
Range	0–40°C
Dimensions	
Width	203mm (8in)
Depth	216mm (8½in)
Height	260mm (10¼in)
Weight	7.5kg (16½lb)

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Marconi's 1907 c.w. transmitter

In his letter in the April issue your correspondent Mr W. L. E. Miller states that "The assertion that Marconi had produced a c.w. system using a spark discharge around 1907 cannot be substantiated although the myth has been perpetuated in Baker's recent 'A History of the Marconi Company' ".

May I refer Mr Miller to a lecture given by G. Marconi and entitled "Transatlantic Wireless Telegraphy" which he delivered at the Royal Institution on 13 March 1908? I enclose copies of two relevant pages of his address for your scrutiny.* From this it will be seen that Marconi, after mentioning the initial tests between his new station at Clifden and Glace Bay in 1907 (using the conventional spark system), goes on to say:

"Simultaneously with these tests others were carried out from Poldhu to Glace Bay with a new system of transmitting apparatus, by means of which continuous or semi-continuous oscillations could be produced.

"Proportionately to the energy employed, the signals from Poldhu were so much better than those from Clifden that I decided at once to adopt this new method of transmission at Glace Bay and Clifden. The apparatus which I have been using for producing continuous or closely adjacent trains of electric oscillations is as follows:—"

(Here follows a description)

From this wording it might be inferred that Marconi was not sure whether the waves were continuous or semi-continuous! Not so, however. In the text which follows he makes it clear that the original apparatus produced continuous waves and that he deliberately introduced a modification to provide "a regular succession of trains of undamped or slightly damped waves" in order to make the received signal audible on headphones. Oscillations to a maximum of 200kHz were obtained. The device was patented on 9 September 1907 (pat. appl. No. 20,119).

The extremely high speed at which the discs had to rotate called for ultra-high

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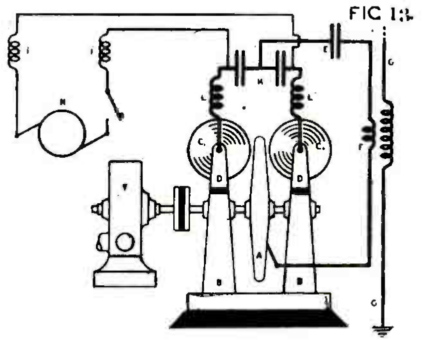


precision in their manufacture. The "Timed Spark" system was a logical development of the 1907 device and in 1913 a British government Commission reported more favourably on this than on any other continuous wave system then in use (See Dowsett, H.M. "Wireless Telegraphy and Telephony", Wireless Press Ltd, 1920).

W. J. Baker,
Chelmsford,
Essex.

*Held in editorial office. A piece of the document is reproduced with Mr Baker's letter. — ED.

Audio amplifier design

There are several points that we would like to make in connection with recent contributions from Messrs Walker, Linsley Hood, Fison and others on the problem of low noise and low distortion audio amplifier design.

It can be shown[1] that the noise a transistor may generate (Fig. 1) under set conditions of source resistance, collector current, etc. can be represented by a voltage generator V_{NQ1} looking into a perfect voltage amplifier of gain A_{10}. This voltage generator is in series with the noise voltage generated by the source resistance itself V_{NRS}. These can be considered as representative of the two dominant sources of noise in an amplifying stage. It is clear that at the collector of the first stage there will be a noise voltage derived from the input, of magnitude

$$A_{10}(V_{NQ1}^2+V_{NRS}^2)^{\frac{1}{2}}$$

If the next stage (second or subsequent stages being treated as one) is again considered in the same way as the first, there will be a noise voltage at the input of the stage of

$$V_{IN} = (A_{10}^2(V_{NQ1}^2+V_{NRS}^2) + V_{NRC1}^2+V_{NQ2}^2)^{\frac{1}{2}}$$

where V_{NRC1} is the noise generated by the collector resistor of the first stage and where V_{NQ2} is the noise generated by Tr_2 referred to the input. Thus the total output noise will be

$$V_O = A_{20}V_{IN}$$

The above statement applies to the open loop case. If we now close the loop the output noise voltage is V_{ON} and so at the emitter of Tr_1 we have

$$V_f = \frac{V_O R_{e1}}{R_f}$$

where:

$$V_O = A_{20}[A_{10}^2(V_{NQ1}^2+V_{NRS}^2) + V_{NRC1}^2+V_{NQ2}^2]^{\frac{1}{2}} + A_{10}V_f$$

rearranging:

$$V_O - \frac{A_{10}A_{20}V_O R_{e1}}{R_f} = A_{20}[A_{10}^2(V_{NQ1}^2+V_{NRS}^2) + V_{NRC1}^2+V_{NQ2}^2]^{\frac{1}{2}}$$

therefore:

$$V_O = \frac{A_{20}[A_{10}^2(V_{NQ1}^2+V_{NRS}^2) + V_{NRC1}^2+V_{NQ2}^2]^{\frac{1}{2}}}{1+\frac{A_{10}A_{20}R_e}{R_f}}$$

From this one can see that if the noise contribution of the second stage is to be negligible compared to that of the first then $A_{10}(V_{NQ1}^2+V_{NRS}^2)^{\frac{1}{2}}$ must be greater than $(V_{NRC1}^2+V_{NQ2}^2)^{\frac{1}{2}}$. To give an illustration, for a noise contribution of 0.1dB by the second stage, A_{10} needs to be 20dB greater than A_{20}. This is just another factor in design compromise, but in general, when designing a low noise amplifier, more gain should be obtained from the first stage and a split emitter resistor can be used to reduce the open loop voltage gain of the second stage. The increase in coupling factor will

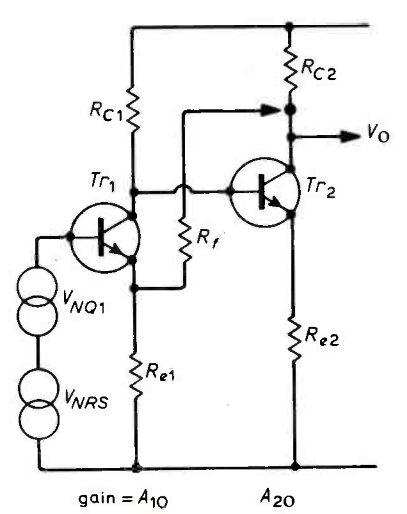


Fig. 1. (Refer to text.)

in part make up for this loss in the overall open loop voltage gain of the amplifier.

To draw a conclusion, this is the reason why Mr Linsley Hood's Liniac based circuits have as low a noise figure as they do, and Mr Walker's series feedback circuits (*W.W.* May 1972, p. 234) could be yet quieter, the latter not having the noise contribution of the resistor in series with the input as well as that of the signal source.

Secondly, we have repeated Mr Linsley Hood's experiments with a 741 (*W.W.* Jan. 1973, p. 11) and when using a signal with a very low distortion we were unable to measure any difference between the shunt and series feedback configurations.

Thirdly, with reference to Mr Fison's statement (*W.W.* March 1973, p. 120) concerning Mr Linsley Hood's *Hi-Fi News* power amplifier, we have found that although the design claims justifiably 0.01% t.h.d. at 1kHz, the distortion rises with frequency, for example typically 0.06% at 3kHz and 0.2% at 10kHz. Whether or not this distortion is audible is another matter. However the rise in distortion is largely due to the early falling off of the loop gain with increase in frequency and consequent change in phase of the feedback relative to the input signal; this applies to many designs on the market.

Finally, as has been known for a long time but perhaps not fully appreciated, it doesn't matter how much feedback is applied to reduce distortion, unless it is negative and the phase is correct at all frequencies it will not improve the amplifier's overall performance.[2] Obviously any design which takes this into consideration will herald a new generation of amplifiers in terms of low distortion and low noise.

A. R. Mornington-West, J. Vereker,
Salisbury.

1. Faulkner. "The Design of Low-noise Audio-frequency Amplifiers", *The Radio and Electronics Engineer*, Vol. 36, No. 1, July 1968.
2. Linsley Hood, J. L. Private communication. Murphy, R. "Power Semiconductors", *Electron*, 8 March 1973.

An attempt was made during the development of a linear a.f. power amplifier[1] in the early part of 1971 to evolve a design in which the "square wave" response was free from overshoot on a reactive load. To this end, attention was paid to the design to make sure that the phase error of the amplifier was low up to the highest practicable frequency (in practice this is probably limited by the transition frequency of the output transistors chosen), and a single dominant lag was then interposed within the amplifier chain to generate a predictable gain and phase margin.

When this was done, it was found that the harmonic distortion was also lower than had been anticipated, and it was apparent, on consideration, that the reduction in the phase error of the amplifier chain within the frequency range of interest also reduced the ineffective quadrature components in the feedback loop and allowed more effective distortion cancellation. One might say that negative feedback is indeed an effective way of reducing distortion but only so long as it is negative.

In the particular case of class B push-pull output stages, where the signal is routed alternately through the two halves, the phase characteristics of these may well be different unless externally corrected, and it seems probable in retrospect that the improvement which I found to be given by the addition of a capacitor across Mr Baxandall's series corrector diode in the quasi-complementary pair was due to the matching of the phase lags of the two halves.

It should be remembered when carrying out this exercise that the high frequency phase characteristics are influenced by both circuit stray capacitances and lead impedances, so that if the mechanical layout of the amplifier is changed the phase error may also be changed and the phase trimming may need adjustment.

Once adequate loop stability is assured, the required transient response will be given so long as the rate of change of gain with frequency does not exceed — 6dB / octave. This is probably most easily achieved in practice by the inclusion on the input of the amplifier of a simple *CR* integrating circuit. This also protects the amplifier from shock-excitation or transient overload.

J. L. Linsley Hood,
Taunton,
Somerset.

Reference

1. J. L. Linsley Hood. *Hi-Fi News*, Nov. 1972.

Series resonant circuits

The other day a student of mine asked why series resonant circuits were not more widely used in communications equipment because they could be tuned by the capacitor and would then give a constant bandwidth over the tuning range.

This is true of course for simple series circuits whatever the coil Q-factor may be, the bandwidth being

$$\frac{R_t}{2\pi L},$$

where R_t is the total series resistance in the circuit in which the signal appears.

The same is true if R_t and L are placed in parallel with the tuning capacitor, provided that the Q-factor is greater than 10 or so. It is only when, in practice, this parallel circuit is fed from a source, or loaded by another system (such as transistor tuned amplifiers), that we get a tuned circuit which can be represented by the duals of R_t and L, so that the three components, R_t', the dual of R_t, L', the dual of L, and C, are placed in parallel, with L' assumed to have a high Q-factor, as above.

Then the bandwidth is given by

$$\frac{1}{2\pi CR_t'}$$

and varies with the setting of the tuning capacitor. This, in practice, means that the Q-factor will be as much determined by the circuit shunt resistance (R_t') as by the self resistance of the coil, so that the selectivity will not vary as much as one might think if the ratio of the highest and lowest tuned frequencies is close to unity.

Apart from quickly seeing why series circuits cannot be used in collector circuits, the student was essentially satisfied by the explanation given above. I trust it was sound and practically sensible?

Roger C. Driscoll,
Polytechnic of North London,
London N.7.

Solid-state teleprinter demodulator

I was interested to read the article in the February *Wireless World* on a solid state teleprinter demodulator, since I am in the process of setting up an amateur two-metre RTTY station. Like Mr Addie, I felt that i.cs have much to offer over earlier techniques. In particular I have used a p.l.l. i.c. to discriminate between mark and space frequencies. This has proved exceptionally easy to set up for a.f.s.k. as used by amateurs on v.h.f. The tracking filter, as it is sometimes called, would appear to offer a simpler solution to frequency discrimination than the *LC* bandpass filters used by Mr Addie. Tuning fixed inductors at low audio frequencies leads to a multitude of fixed capacitors, whereas fine tuning of the p.l.l. is accomplished by a variable resistor. The same device can also readily resolve different shift frequencies.

In the end, performance under operational conditions is the ultimate test, and I confess that I am a raw beginner in this field. I wonder if the p.l.l. can equal the performance of a well tuned filter. It is certainly easier to use.

J. M. Osborne,
Westminister School,
London, S.W.1.

Reference

"Terminal Unit in Solid State for RTTY". *Short Wave Magazine*, Nov. and Dec. 1972.

Dual-ramp d.v.ms

In view of the increasing interest in the dual ramp technique of digital voltage measurement, evidenced by various recent articles in your pages, I hope you will allow me space to comment on the patent position.

Basic patents covering this technique are held by Solartron/Schlumberger in several industrial countries. These include U.K. patents No. 869,262 and No. 1,090,047.

It has been Schlumberger's practice to grant non-exclusive licences under these patents to responsible applicants. We would be glad to consider an approach from, for example, any firm which is not yet licensed and plans to supply kits or finished equipment using the patented technique.

R. H. Nicholson,
Managing Director,
The Solartron Electron Group Ltd,
Farnborough,
Hampshire.

Doppler distortion in loudspeakers

I had hoped that my letter in the January issue of *Wireless World* would end the correspondence on Doppler distortion but the plea by Mr M. G. Scroggie in the February issue, which has just come to my notice, prompts me to pen a brief answer.

The first point he raises is at least partially answered by Stott and Axon. I quote, "Vibrato of either pitch or intensity in a musical instrument tends to mask fluctuations caused by the recording system (e.g. Doppler*). From this point of view the piano with its complete absence of vibrato, is possibly the most pure tonal generator available; its frequent use in the investigations described was based on this consideration. The organ may speak vibrato from the tremulant stops. An example of pitch-fluctuation threshold variation for light theatre-organ music is shown in Fig. 12 which gives the mean results for nine subjects. As far as comparison with curve (b) of Fig. 10 is possible, the threshold is seen to be greater than that for piano programme material except at extreme flutter frequencies".

I doubt whether from the musical aspect a *single* flute stop organ note would be held very long over a *single* pedal note, and the moment a chord is introduced the position becomes radically different. This is illustrated by Mr Moir's letter in the same issue, in which he confirms that the very low values of Doppler distortion he quotes not only require continuous pure tones but also the sharp standing wave patterns in a live room to detect them to this degree. This is confirmed by the ubiquitous Stott and Axon article again in their Fig. 8 which shows a minimum audibility figure for pure tones, *when using headphones,* of as much as 0.15% peak frequency modulation. The large difference in values indicates the tremendous effect the standing wave system in a room has for steady pure tones on the audibility of Doppler effect. This would largely be negated by the use of chords instead of pure tones as the positions for the peaks and troughs would not coincide for the different frequencies, and again by the short time most chords are sounded in programme. (Stott and Axon used slow sustained piano programme to emphasize the effect.)

Perhaps the proof of the pudding is in the eating. In the article quoted in *Jour. Audio Eng. Soc.* for November I have shown that on the basis of the Stott and Axon findings, Doppler distortion should be inaudible at the maximum rated power on all three of the latest types of B.B.C. monitoring loudspeaker by values ranging from 7 to 12 dB. In practice no complaint of such distortion has ever been made about these loudspeakers on any type of programme whatsoever, whereas if the figures for pure tones were applicable Doppler distortion should be plainly heard.

H. D. Harwood,
B.B.C. Research Dept.,
Kingswood Warren,
Surrey.

* My addition

Open University course

I was particularly interested to read the article on the Open University Post Experience Course as I am one of this year's students — currently up to Unit 5, Semiconductor Devices. I would echo the author's opinions concerning the presentation of the work as anything less like my old text-books is hard to imagine — plenty of space for margin notes, colour in the diagrams, photographs of equipment etc.

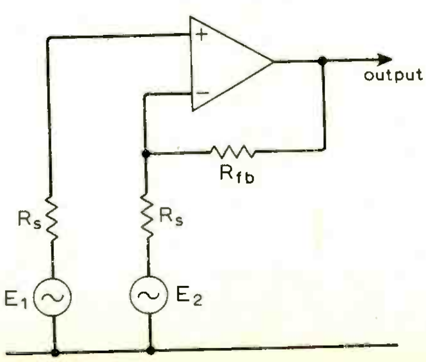
Prospective students should not be put off by a lack of BBC-2 as the programmes (although desirable, of course) are not essential viewing for continuity.

In conclusion, may I take the opportunity of thanking you for the "back-up" given by the journal — two articles on magnetic topics by Cathode Ray, and a series of four on the development of semiconductors.

P. J. Hunt,
St. Saviour's Hill,
Jersey,
C.I.

Feedback amplifiers

If I might reply briefly to Mr Walker (Letters, April issue) on the particular point of the noise levels in shunt feedback circuits, leaving aside for the moment the case of a frequency dependent feedback loop, the situation can be clarified by reference to the accompanying drawing. If we postulate two zero-output, zero-impedance, generators, E_1 and E_2, connected to the inputs of a notional operational amplifier by means of two



resistors (R_S) of the appropriate value to optimize the input noise characteristics, the output noise of the amplifier will be the same whichever of the two generators we assume to be providing the zero input.

If however, we increase the output from one or other of these, to some suitable (and identical) value, the signal-to-noise ratio will depend on the extent to which the signal is attenuated between source and amplifier. In the case of the series circuit this is normally very little; in the case of the shunt circuit this depends on the input shunt impedance of the amplifier device. With suitable operating parameters this will be in the range 4-6 dB, and this is the intrinsic loss in this arrangement. Moreover, the noise impedance seen by the input in the shunt feedback case is not the input resistor circuit value, but the value of the "virtual earth" impedance, and noise measurements suggest a value of 600-1200 ohms for this. This is in line with the observed noise values, which can be as low as 0.6 μV, whereas the thermal noise of an input 47kΩ would be some 3.9 μV (20kHz bandwidth, 300°K).

I agree with Mr Walker that the use of an R.I.A.A. equalized circuit changes this case by altering the special distribution of the noise but this also makes it difficult to specify what the noise figure is in respect of an input signal which also is assumed to increase with frequency.

J. L. Linsley Hood,
Taunton,
Somerset.

"Biamplifier" loudspeakers

We read with interest Mr Hiscocks' letter in the March issue, commenting on Mr Kelly's article on loudspeakers. We note particularly his comments concerning the use of active crossover networks and the use of separate power amplifiers for each loudspeaker. The Gabraphone 2001-6 Reproducer System employs a highly developed form of exactly this principle.

Following the pre-amplifier stages, the audio frequency range is separated into three bands by filters. A user control is provided for each band to permit individual adjustment of the lower, middle, and upper registers. The separate signals are then passed to individual power amplifiers, 6 in all, each of which drives an associated loudspeaker unit in the specially designed enclosure.

Our observations and measurements confirm the freedom from intermodulation distortion which you anticipate, as well as the elimination of transient distortion introduced by the conventional passive crossover network.

In our view, the additional cost of this system is well justified by the improved quality of results obtained, and evidently the discriminating customers who purchase this equipment agree with us.

S. Gabr,
Modern Engineering & Technology Ltd.,
Canterbury,
Kent.

Industrial Electronics

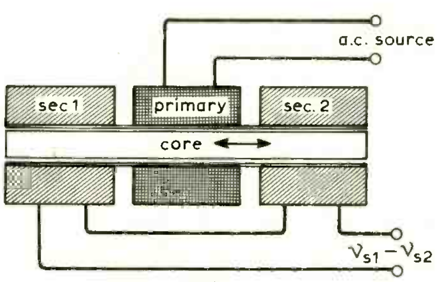
3. Inductive and capacitive displacement transducers

by Richard Graham

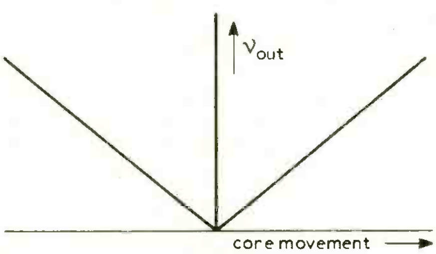
The absolute method of displacement and position measurement described in the last article is one of the most accurate and reliable known to man of positioning the workpiece in a machine tool. It must be admitted, though, that it comes expensive. Furthermore, other applications in which position measurement is carried out may not need the ultimate in accuracy, long-term stability, digital read-out and friction-free operation. The engineer must be a practical man, and it makes good sense to provide the required performance at a reasonable cost, and not to saddle whoever is paying the bill with more accuracy, etc. than he can use.

Inductive transducers

Considerably cheaper, but still accurate and extremely sensitive, is the linear variable differential transformer — a device which is substantially easier to use than to say. Fig. 1(a) is a sketch of the transducer in which are shown a primary and two secondary windings on a common, cylindrical former. The secondaries are wound in phase opposition, and the three windings are penetrated by a core, which is movable axially. When the core is in the centre position, the magnetic flux linking the primary to the secondaries, *via* the core, is equally distributed, so that the output difference voltage is zero. As the core moves to favour one secondary, the voltage from that secondary increases at the expense of the other and a difference voltage appears. Moving the core in the opposite direction by the same amount produces a difference voltage of the same amplitude but of opposite phase. The core movement/output voltage characteristic, neglecting phase, is shown in Fig.1(b). Departures from linearity are of the order of 0.25% of end-to-end output, and at the origin, there is not a perfect null unless steps are taken to provide one by external electrical means.



(a)



(b)

Fig. 1(a) Sectional drawing of l.v.d.t. (b) Output signal from the l.v.d.t. In a phase-sensitive detector the left side would be negative.

Unless the core is required to pass the centre position, the output can be indicated directly by an ordinary pointer-type instrument of high impedance or by digital voltmeter. For full-range indication, a phase-sensitive meter is, of course, required. The transducers can be obtained in ranges from 0.05in to 10in, full-scale, the output being in the order of 0.02mV to 2mV per volt applied per 0.001in displacement.

This transducer has much to recommend it. Mechanically, it is simplicity itself. There is no friction and the device is invulnerable to hard use and hostile industrial environments. The alignment of the moving core is not critical and there are no rubbing surfaces to wear. Electrically, while not as linear as the digital type of transducer, it is adequately accurate for the majority of applications. It has a continuous characteristic, providing an infinitely small resolution, and it is mechanically and electrically stable.

Applications of the l.v.d.t. are numerous and range from pressure measurement to the determination of acceleration; any parameter, in fact, in which the variable can be turned into a linear movement can be measured by an l.v.d.t. system. An interesting application is that shown in Fig.2, where the static l.v.d.t. is being used to determine the eccentricity of a lorry tyre. The system is by Sturge Automation[3] and is capable of detecting eccentricities of 0.002 inch on a 40-inch tyre. Similar systems, using multiple transducers, are in use to detect variations in the thickness of continuous sheet material during manufacture. The output is presented digitally.

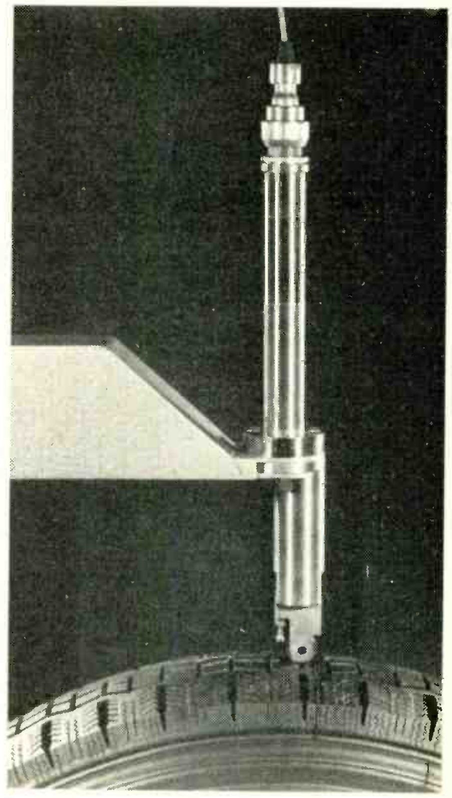


Fig.2 Tyre eccentricity measurement by Sturge Automation. As the tyre turns, the output of the transducer is recorded.

L.v.d.ts can be used to measure acceleration by the arrangement of Fig.3. In this type of instrument, the windings are stationary relative to the body whose acceleration is being measured, the mass of the core and associated spring flexures being free to move. The deflection of the core is proportional to the applied force due to acceleration.

The testing of metallurgical specimens is an application in which the l.v.d.t. excels by virtue of its linearity and stepless output. Fig.4 shows such a measurement suggested by Schaevitz[1], in which a tensile test specimen is being extended, the

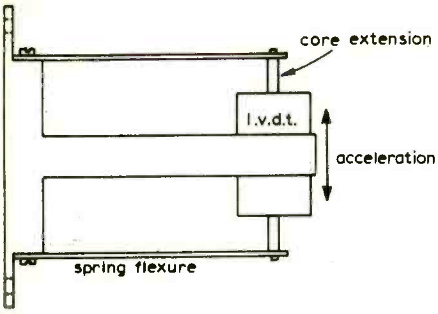


Fig.3 The l.v.d.t. in an accelerometer application.

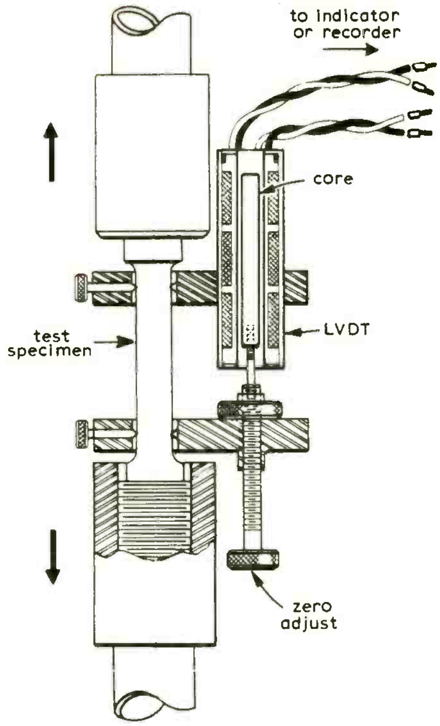


Fig. 4. When used in an extensometer, the core is completely free to move and is not damaged when the specimen breaks.

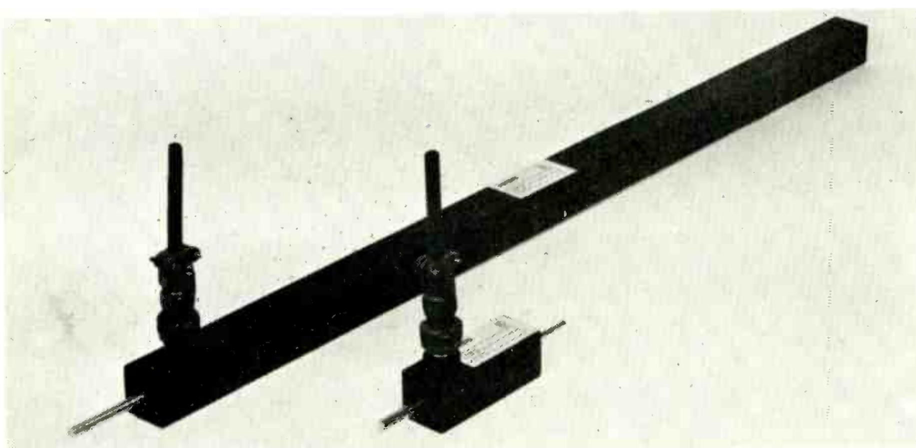
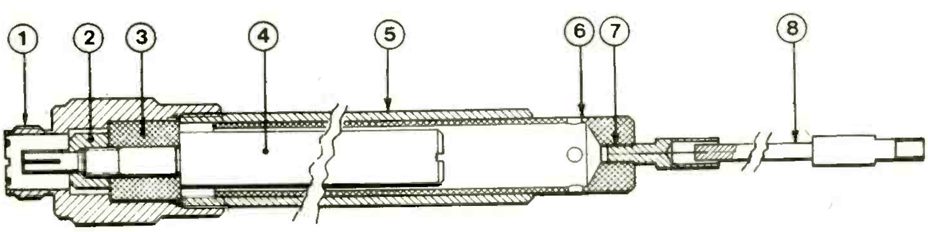


Fig.5 The LD5000 inductive half-bridge transducer by Philips.



1. Adapter, stainless steel, 27 mm dia.
2. Special nut, brass
3. Insulating bushing, polystyrene
4. Inner electrode, stainless steel
5. Outer electrode, stainless steel, 20 mm dia.
6. Dielectric tube, polystyrene, 16 mm dia.
7. Threaded insert, 3-mm metric thread
8. Coupling section, aluminum

Fig.6 The DISA dielectric-change transducer type 51DO5.

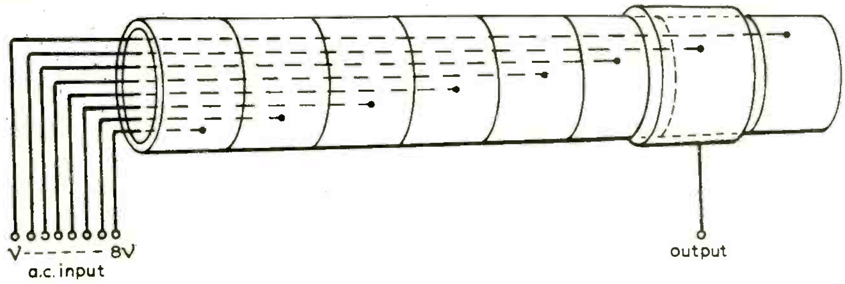


Fig.7 Rank Precision capacitive displacement transducer.

l.v.d.t. being used to measure the extension. The core and windings are, of course, completely separate, so that when the specimen ruptures, no precautions are necessary to prevent damage to the l.v.d.t.

Similar, in some respects, to the l.v.d.t. is the half-bridge inductive transducer. It consists of a tube of non-magnetic material, on which are wound two coils forming two arms of a bridge network. A ferromagnetic core moves in the tube, varying the inductance of the coils differentially and unbalancing the bridge, which is completed by resistive arms. These devices possess the advantages of the l.v.d.t. and are cheaper to make, measuring from ± 1 millimetre to ± 150 millimetres at a maximum non-linearity of less than 2% of stroke. Philips[2], in common with other manufacturers, provide a range of signal generation and handling equipment. In conjunction with this equipment, it is possible to obtain full-scale deflection at the indicator for a deflection of one micron.

Capacitive transducers

As may be expected, the "other" property, capacitance, can also be exploited to obtain displacement measurement. The capacitance of two plates is proportional to kA/D, where A is the area of overlap, k is the dielectric constant and D is the distance between the plates. The variation of any one of these parameters will produce a capacitance change, and all three have been used in commercial equipment. To derive a useful output from the capacitance change, the variable capacitor is made a part of the tuning element in an oscillator's tuned circuit, the resulting frequency modulation being detected and used to operate the desired output device. In the case of the transducer working with plate separation as the variable, the distance/capacitance characteristic is hyperbolic and requires an electronic linearizer to give a true indication. Disa[4] manufacture a range of capacitive displacement transducers, together with signal processing equipment, and Fig.6 shows their Type 51DO5, which is of the dielectric-change variety. The change in capacitance as the dielectric tube moves axially is linear with displacement. This type is intended to measure large axial movements up to 7cm and, as the coupling section is hinged, can be used to convert rotary movement into linear displacement. In this way, it is valuable as a piston stroke transducer in the investigation of i.c. engine operation.

The measurement of large displacements is also the function of a system made by Rank Precision[5] (originally by Reilly Engineering) shown in Fig.7. In this case, a series of cylindrical electrodes are arranged end-to-end in the form of a rod. Sliding over the rod is a cursor cylinder exactly equal in length to one stator segment or a multiple thereof. Each segment is fed from a tap on a voltage-dividing transformer, the voltages increasing arithmetically in amplitude. The cursor is coupled purely capacitively to the stator segments and the voltage output

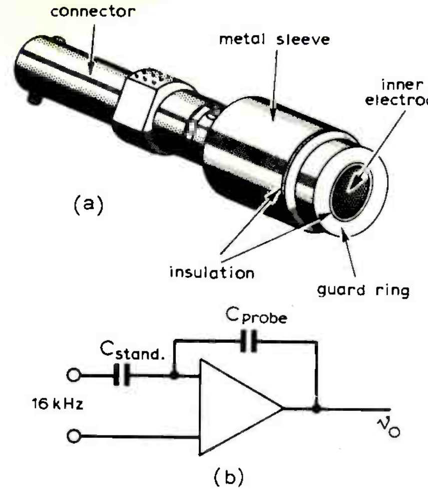


Fig. 8 Wayne Kerr capacitive probe system.

from the cursor increases continuously as it moves from the low-signal end to the other. To take account of any errors in length of the stators or inaccuracy in the transformer taps, additional variable voltage sources are connected in series with the taps, the voltages applied to the stators thereby being capable of slight variations. The output of the cursor is measured by nulling a bridge circuit, which gives a degree of immunity to supply voltage variations. Accuracy of measurement is extremely high, the error over a 20-in transducer amounting to no more than 0.0001 in peak to peak.

Applications include the calibration of automatic machine tools, high-speed measurements on machines where a digital system may be subject to error, and materials testing where long-term stability is required as in the measurement of creep. Short-range transducers are also made, and consist of only two stator segments and a cursor, an arrangement which is effectively a differential capacitor.

The Wayne Kerr[6] Dimeq TE200 range of equipment is another embodiment of the variable capacitance technique. Fig. 8 shows a sketch of the principle, in which one "plate" of the capacitance in question is the transducer. The other electrode is the metallic structure under examination, which is connected to the instrument ground. The capacitor formed by the probe and structure is made the negative feedback element in a high-gain amplifier, to which is applied a constant-amplitude 16kHz signal. If it is assumed that the open-loop amplifier gain is very high, there is a virtual earth point at the junction of the fixed *C stand* and the probe capacitance *C probe*. The closed-loop gain of the amplifier is proportional to the reactance of the probe capacitance, which is proportional to *d*, the distance between the probe and the earthed structure. The output signal is therefore directly proportional to this distance. The application of the system lies in the measurement of vibration, thickness, bore diameters and eccentricities and is capable of indicating displacements in the range 0.5mm to 2.5mm.

The transducers and systems described in these two articles have been selected from a large number of devices currently in use, employing the properties of capacitance, inductance, resistance and ultrasonics to provide the detection and measurement of position, displacement and distance. Many more exist, and it is not intended to imply that the types that are not described are inferior — it is simply that the choice is limited by space.

In the next article, I shall deal with the use of electronics in the weighing industry.

References

1. Schaevitz Tech. Bulletin AA-1b, Electro Mechanisms Ltd., 218-221 Bedford Avenue, Slough, Bucks.
2. Pye Unicam Ltd., Philips Electronic Instrument Dept., York Street, Cambridge CB1 2PX.
3. Sturge Automation Ltd., Lifford Lane, Birmingham B30 3JP.
4. DISA, 116 College Road, Harrow, Middlesex HA1 1HQ.
5. Rank Precision Industries Ltd., Leicester House, Lee Circle, Leicester LE1 9JB.
6. The Wayne Kerr Co. Ltd., Durban Road, Bognor Regis, Sussex, PO22 9RL.

Sixty Years Ago

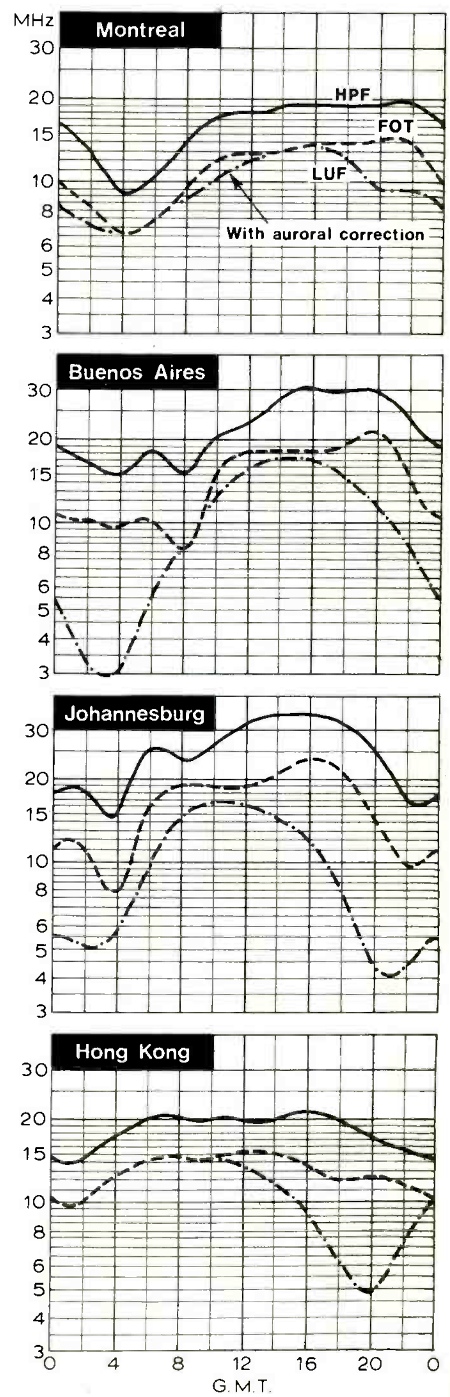
This was the first issue after the launch of the journal under its new name. Although wireless telegraphy ceased to be our prime concern some time ago, the broad aims of *Wireless World* appear to have remained substantially the same.

"In presenting the first number of THE WIRELESS WORLD last month, we do not think we were unduly sanguine in thinking that it would occupy a place in periodical literature which has hitherto been left unfilled. Its reception has justified the opinion that the magazine would meet a distinct need, and the cordial welcome which it has received from all quarters and from the technical and general Press encourages us to look for the rapid achievement of our object to make it 'a magazine for everyman'. The first number had an issue of fifty thousand copies, but, large as this quantity may appear, it was by no means too large to cope with the demand. An encouraging feature was the numerous 'repeat' orders from newsagents and booksellers in all parts of the country. These facts are worth mentioning because they illustrate more strikingly than anything else can the great public interest in the subject of wireless telegraphy, and their eagerness to read about it when the subject is presented in such a manner that it will not be beyond their scope."

H.F. Predictions — May

These notes are prepared during the first few days of the month prior to publication, which unfortunately precludes basing the ionospheric "weather" forecasts on observations made during the month immediately preceding the forecast month. However, over the few years of a sunspot minimum which is expected at the end of 1974, advance forecasts can meet with moderate success.

There was a prolonged magnetic disturbance at the end of March which will almost certainly recur from the 13th to 20th May with a possible extension to the 25th. The first part of the month is expected to be quiet, the period 8th to 12th being the most favourable.



About People

Thames Television has appointed **Brian G. Scott**, M.I.E.E., to become head of engineering, and **A. J. Rickards**, M.I.E.R.E., as deputy head of engineering. Mr Scott joined ABC TV in 1961 in technical operations, following design and systems experience on closed circuit television. He was transferred to Engineering Projects in 1964, and made deputy head of engineering for Thames in 1968. He became head of engineering projects in 1970. Mr Rickards joined ABC TV in 1960 from E.M.I. He was head of engineering, planning and installation in 1968 for Thames, and subsequently became head of the development and maintenance department.

Among those recently elected Fellows of the Royal Society are the following:
Professor W. J. G. Beynon, C.B.E., Ph.D., D.Sc., A.M.I.E.E., professor of physics in the University College of Wales, Aberystwyth. He is distinguished for his work in ionospheric studies and for his rôle in the organization of the International Geophysical Year and the International Years of the Quiet Sun. **J. G. Bolton**, B.A. (Cantab), is director of the Australian National Radio Astronomy Observatory and is distinguished for his contributions to radio and optical astronomy, the development of instruments and the optical identification of radio sources. **Professor H. H. Hopkins**, Ph.D., D.Sc. (Hon), who is professor of applied optics at the University of Reading, is known particularly for his work in theoretical and applied optics, especially the wave theory of aberrations, fibre optics and the zoom lens.

Roy Blythen has been appointed to the Board of E.M.I. Sound & Vision Equipment Ltd, at Hayes. Joining E.M.I's research laboratories in 1934, Mr Blythen became involved with the development work which led to the first high-definition television system in 1936. As part of the E.M.I. television research team, led by Sir Isaac Shoenberg, he was primarily engaged in the design of the transmitting equipment used for broadcasts from Alexandra Palace. During the second world war, he worked on the first form of airborne radar which E.M.I. developed and manufactured during this period. In 1945, he returned to research and development work on television transmitters and aerial systems until 1957 when he transferred to the Broadcast Equipment Division. When E.M.I. Sound & Vision Equipment Ltd was formed in June 1972, he was appointed general manager of the Telecommunications Division.

Sinclair Radionics has appointed **Mike Pye, M.A.** (Cantab), as research and development controller. Mr Pye was previously consumer branch manager of Texas Instruments, Bedford, where his work included the design and development of linear integrated circuits. He joined T.I. four years ago from Plessey.

L. A. Smulian, B.Sc., previously general manager, Transmission and Electronic Exchanges division, Plessey Telecommunications, has been appointed managing director of the Plessey Microsystems division. Mr Smulian has been with Plessey since 1966 when he joined Plessey Radar as manager, Display and Data division.

Two major appointments within Plessey Memories are also announced. **Bernard J. Hadley**, F.I.E.E., who for the past five years has been managing director of International Rectifier Company (GB) Ltd, joins Plessey to head the Memories marketing activities. Appointed operations executive (world-wide) to control the Plessey Memories production programme is **Alan W. Jones, M.A.**, who was works director, Keith Blackman Ltd.

The secretary of the Society of Electronic & Radio Technicians, **Anthony J. Kenward**, B.Sc., A.M.I.E.R.E., has been appointed a member of the Technician Education Council by the Secretary of State for Education & Science, Mrs Margaret Thatcher. Mr Kenward was educated at Haberdashers Aske's School and Sexey's School, Bruton. He studied physics at the Polytechnic, Regent Street, and obtained an external London degree in 1946. His experience includes 16 years on the staff of the Institution of Electronic & Radio Engineers as education officer responsible for all membership, education and examination activities. During this period he was a joint secretary of the Joint Committee for Higher National Certificates & Diplomas in Electrical & Electronic Engineering. He has been secretary of S.E.R.T. since its formation in 1965, and of the Radio Television & Electronics Examination Board since the same date. He is currently chairman of the Technician Engineer section of the Engineer's Registration Board.

The board of British Insulated Callender's Cables has announced that **Lord McFadzean** has decided to relinquish the chairmanship and retire from the board in May, after almost 41 years' service. The board has accepted his decision with regret and, in recognition of his outstanding contribution to the B.I.C.C. group has elected him as Honorary President for life, in which capacity his wide experience will continue to be available to the company for certain special services and for consultation. **William Fraser**, C.B.E., at present deputy chairman and chief executive, will relinquish these positions and succeed Lord McFadzean.

Hewlett-Packard have announced the appointment of **Robert Somerville** as the television studio manager in their plant at South Queensferry, West Lothian. Mr Somerville's appointment is unique in Scotland as this is claimed to be the first television studio to be opened by an industrial organization. He will take up his appointment almost immediately and undergo intensive training in the company's German factory, where a studio has already been established, and later at Heriot Watt University.

Richard Foxwell, C.B.E., a founder director of Wayne Kerr, and its chairman since 1958 when the company became a member of **the Wilmot Breeden group, has** retired from the board. Mr Foxwell was appointed C.B.E. in 1967 for services to export. He was president of the Scientific Instrument Manufacturers Association from 1969 to 1971.

Ian A. Denny, B.Sc (Eng), has been appointed chief executive of BEPI Electronics Ltd., Galashiels, specialist manufacturers of printed circuits, on the retirement of **K. G. Mill.** Mr Denny joins BEPI from the P. E. Consulting Group Ltd where he was senior consultant for eight years. He was previously with the Plessey Group. He was born in Glasgow and educated at Berwick County Grammar School and Edinburgh University.

UCC Computer Instrumentation Ltd have just announced the appointment of **David Sanders** as o.e.m. manager for their Digital Equipment division, with responsibility for engineering support before and after delivery of equipment. Mr Sanders has considerable experience in the solution of o.e.m. problems in the field of computer and d.p. engineering, having completed three years as the senior sales engineer dealing with the division's Southern Region customers. Prior to joining C.I.L. he served in various commercial engineering capacities with Plessey Automation over a period of eight years, where he was involved technically with many forms of computer peripheral equipment.

H. Kenneth Jolly, M.A., has been appointed director of the British Radio Equipment Manufacturers Association and chairman of the executive council of the Association. He succeeds **Sydney Allchurch**, O.B.E., who, as we announced in the April issue, has retired. Mr Jolly has been secretary of the Association since September 1966. During that period he has been particularly associated with the promotion of colour television in Great Britain, with the television and radio industry's preparations for entry into Europe and with studies on imports of consumer electronic products.

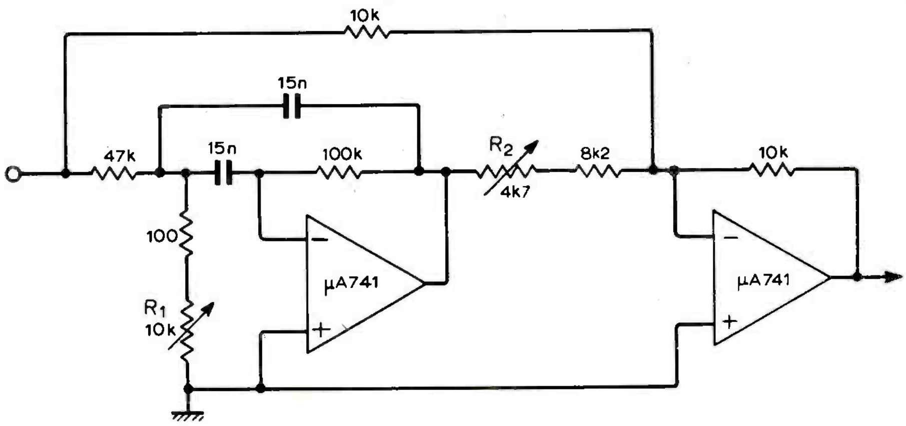
John Lewis, B.Sc. (Eng), of the B.B.C's engineering designs department is going to Beaverton, Oregon, U.S.A, for six months to undertake a design exercise in collaboration with Tektronix Inc. Mr Lewis, who is a graduate of London University, has for a considerable time been working on the design of specialized units to be used in connection with oscilloscopes for monitoring broadcast television signals. Mr Lewis will conduct the final stages of his investigations in the Tektronix laboratories.

Among the annual awards presented by the I.E.E.E. in February were the Edison Medal and the Founder's Medal. The former was awarded to **Dr B. D. H. Tellegen** "for a creative career of significant achievement in electrical circuit theory, including the gyrator". After receiving a degree in electrical engineering from the Technical University of Delft, Holland, he spent his career with Philips Research Laboratories in Eindhoven, retiring in 1962 after 38 years. The Founder's Medal was presented to **W. R. Hewlett** and **D. Packard** "for leadership in the development of electronic instruments, for creative management and for public service". Messrs Hewlett and Packard started their company in 1939 and now employ over 18,000 people internationally. Mr Packard is chairman of the board, and has been U.S. deputy Secretary of Defence. He is a member of the National Academy of Engineering. Mr Hewlett is president and chief executive officer of Hewlett-Packard.

Circuit Ideas

Concise descriptions of new circuits are invited for Circuit Ideas, for which £5 is paid on publication. Contributors should say how their circuit is an improvement over existing circuits, preferably in the first sentence.

Simple tunable notch filter



Most active *RC* notch filters are difficult to tune because the rejection at the notch frequency depends on the accurate ganging of several potentiometers or variable capacitors (three in the case of the twin-T filter). The circuit shown has a notch frequency which can be varied by one potentiometer only, the notch rejection being independent of the setting and the bandwidth between points of 3dB attenuation on either side of the notch being independent of the frequency to which the filter is tuned. The circuit consists of a bandpass filter tuned by R_1 followed by a virtual earth summing circuit that adds the output of this filter with the input signal. Notch rejection is set to maximum by adjustment of R_2. Using the values shown the filter tunes from 170Hz to 3kHz, a bandwidth between 3dB points of 230Hz and a notch rejection of better than 40dB over the complete range. A voltage-tuned notch filter may be realised by replacing R_1 with a f.e.t. operated as a voltage-variable resistor.

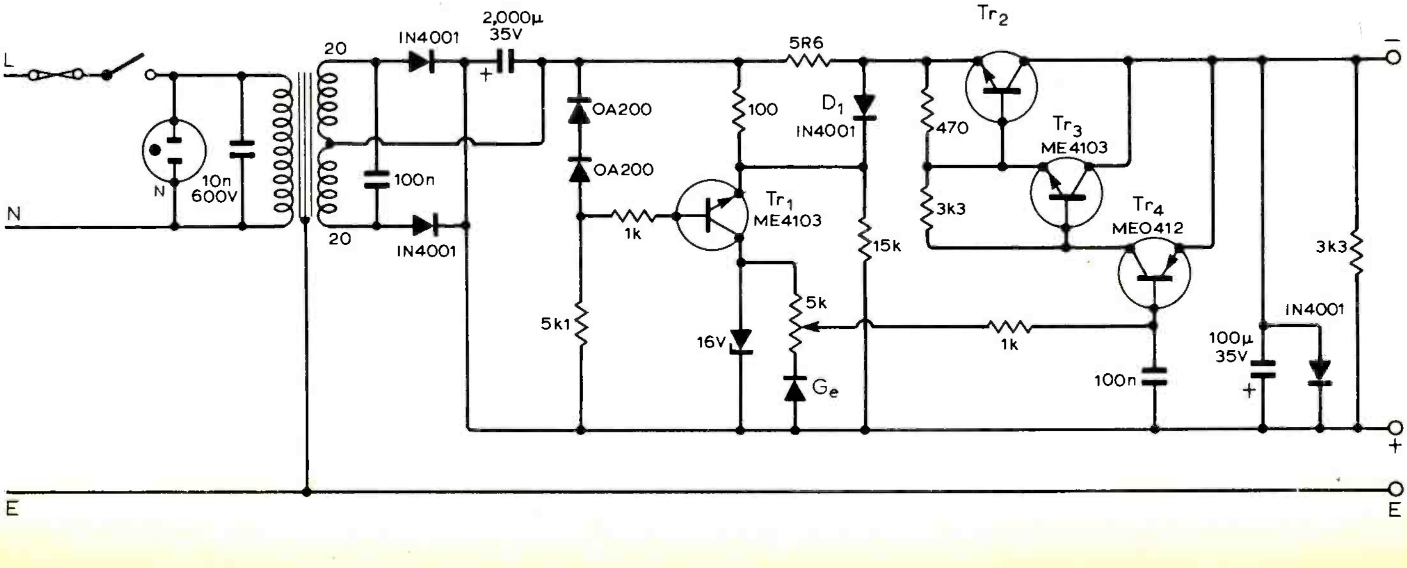
R. J. Harris,
Wells,
Somerset.

Bench power supply

The circuit shown provides 0 to 15V and a current up to 175 mA. Current limiting is provided by the 5.6-ohm resistance and the diode D_1. When the voltage across the 5.6-ohm resistance exceeds about 1.2V, the current source Tr_1 produces less current and the output voltage is reduced.

The 15-kΩ resistor from the emitter of Tr_1 provides feedback so as to reduce the current variations through the regulator diode. A 10% line voltage change therefore produces only a 2mV $\pm$ 0.01% change in V_{out}. A full load current change produces a 15mV output voltage change; and the output voltage recovers in 3μs to within 10mV of V_{out} after a full load current change. The three-transistor combination Tr_2, Tr_3 and Tr_4 therefore provides fairly high gain and wide bandwidth. Output impedance at 100kHz is less than 0.3 ohm. Output voltage temperature coefficient depends on the regulator diode temperature coefficient, the base-emitter junction of Tr_4 and, at low voltage, the germanium diode. In this respect the circuit is inferior to conventional circuits and a coefficient of 12mV $\pm$ 0.1%/deg C is achieved. Output ripple voltage is greatly dependent on the Early effect in Tr_4. Using the device shown a ripple of less than 1mV is obtained. Charge storage spikes from the rectifier diodes are removed by the 100nF capacitor across the transformer secondary.

J. A. Roberts,
Merthyr Tydfil.



World of Amateur Radio

New threat to 3.5MHz?

For many years the world-wide "exclusive" amateur allocation of 7000 to 7100kHz has been virtually "occupied" for many hours each day by high-power broadcasting stations — including Radio Peking, Radio Cairo and Radio Tirana (Albania) — working in defiance of the I.T.U's Radio Regulations. China has recently acceded to the International Telecommunications Convention of 1965 but in doing so has entered reservations concerning any adoption of the frequency assignments and utilization of the Radio Regulations, so there is now little reason to hope for any sudden departure of Radio Peking from 7-MHz amateur frequencies.

Equally disturbing is that Arthur Cushen, the well-known New Zealand short-wave listener, writing in *Electronics Australia,* is reporting increasing intrusion by broadcasting stations into the 3.5-3.8MHz band. Although this band is shared by various services and amateurs, nowhere is it designated for broadcasting. So it is in breach of the Radio Regulations that Radio Peking has been using 3.64MHz, Radio Pyongyang (North Korea) 3.56MHz, and a station at Dili, Timor, after many years of operating within an assigned broadcasting allocation on 3.268MHz, has recently moved to 3.665MHz.

On the DX bands

The first quarter of the year has seen a notable series of re-occurring magnetic storms, spaced at roughly 27-day intervals and caused by a persistent group of sun spots on successive passes. While they lasted, these storms produced disturbed h.f. conditions and a general absence of DX reception on 21 and 28MHz. In the initial stages, however, they fortunately tend to produce higher m.u.fs and short spells of good conditions one of which, fortunately, coincided with the A.R.R.L. c.w. contest. Regular fade-outs of this type are generally associated with the declining phase of a sunspot cycle and have reminded many amateurs that we now face further decline in sunspot numbers.

A new 28-MHz beacon, ZC4CY on Cyprus, is now active and has been well received in the U.K.

From September 1, the A.R.R.L. is to cease issuing DXCC awards endorsed for phone only operation – in future this well-known award will be issued without distinction between phone and c.w. operation.

The Russian Antarctic bases now have callsigns with the prefix 4K1 with the particular base indicated by the first letter following the figure 1 (A, Molodezhnaya; B, Mirny; C, Vostok; D, Novolazareskaya; F, Bellinghausen; G, Leningradskaya; and H, Russkaya).

A question of deviation

The rapid growth in the use of frequency modulation techniques by British amateurs in the 144-MHz band has raised the thorny question of compatibility with a.m. operators who complain that f.m. transmissions occupy excessive bandwidth. The a.m. people feel that only true narrow-band f.m. (maximum deviation less than $\pm$ 5kHz) should be used so that the emissions occupy only the same channel width as a.m. But there appears to be no such restriction written officially into the amateur licence, and many of the new and converted f.m. equipments now being used on 144MHz are designed for significantly wider deviations and often cannot be operated efficiently on n.b.f.m. For example, it would seem that where a receiver i.f. of 10.7MHz is used only discriminators based on quartz crystals are really suitable for n.b.f.m. reception and these are still few and far between.

Similar debates have arisen in other countries. Glen Zook, K9STH/5, writing in the American *CQ* magazine states that in the United States the growth rate of f.m. is levelling off, and the f.m. enthusiasts are beginning to look for better equipment. Some of the problems are due to the adoption or adaption of equipments originally designed for use in 25, 30 or even 50kHz channels. When these are used in crowded amateur bands severe adjacent channel interference may be experienced by the f.m. operator – apart from the annoyance to a.m. operators – and the transmitters and receivers often drift excessively in frequency and suffer acutely from intermodulation problems.

Glen Zook believes that the time is rapidly approaching when some of the "ready-to-go" f.m. equipments will have to undergo a major redirection in design. He also believes that better quality crystals need to be used for higher stability with a minimum tolerance of 0.001% and preferably 0.0005% or better, and that equipments suitable for strictly narrow-band operation will appear on the market in the near future.

In many countries the growth of "repeater" operation has been a major factor in the adoption of f.m. In the U.K. the site of the first experimental f.m. repeater, GB3PI, which has been operating for several months at Cambridge, is expected to be changed soon to a much higher site at Barkway, Hertfordshire, about 12 miles farther south and potentially within range of London mobile stations. GB3PI accepts signals on 145.15MHz and retransmits them on 145.75MHz when triggered by a half-second 1700Hz tone burst (see "W.o.A.R.," August 1972).

The first European linear repeater, capable of accepting all modes, is now being tested in Czechoslovakia with the call-sign OK0A, accepting signals on 145.1MHz and retransmitting them on 145.7MHz.

In brief

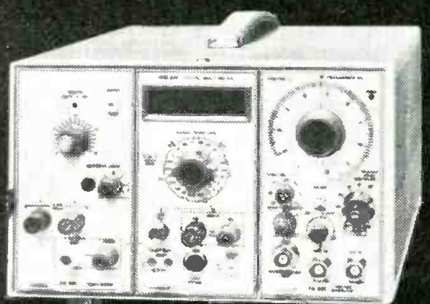
The annual convention of the Northern Radio Societies Association will be held at a new venue – the Forum Halls, Wythenshawe, Manchester – on Sunday, May 6. Member societies will again compete for the G3AYD trophy awarded to the stand giving the best presentation of some aspect of Amateur Radio. There will also be trade stands and talk-in stations and GB2NRS will operate on all h.f. bands (details Peter Taylor, G8BCG, 2 Columbia Avenue, Gorton, Manchester M18 7LG). . . . The South Leicestershire Mobile Rally will be at Westfield Activity Centre, Rosemary Way, Hinckley, Leics, on May 13. . . . Islenzkir Radioamatorar, the National amateur radio society of Iceland, has joined the Region 1 division of the International Amateur Radio Union, bringing the division to 41 member-societies. . . . A change of venue for the R.S.G.B. Dinner Club has been announced from May 4 (Royal Westminster Hotel, Buckingham Palace Road, Victoria, London). . . . Thomas Jenkins (74 Rhos Road, Rhos-on-Sea, Colwyn Bay, North Wales) is writing a book on the exploits of Radio Officers during World War II and would welcome information on personal experiences. His book is being dedicated to the 1500 Radio Officers who lost their lives during the war. . . . Address of the Hon. Secretary of the British Amateur Radio Teleprinter Group has changed recently; it is now 2 Orchard Close, Toddington, Dunstable (Tel. Toddington 2470). . . . The world distance record on 144MHz is an incredible 2540 miles – but it is worth remembering that it was set up as long ago as 1957!

Pat Hawker, G3VA

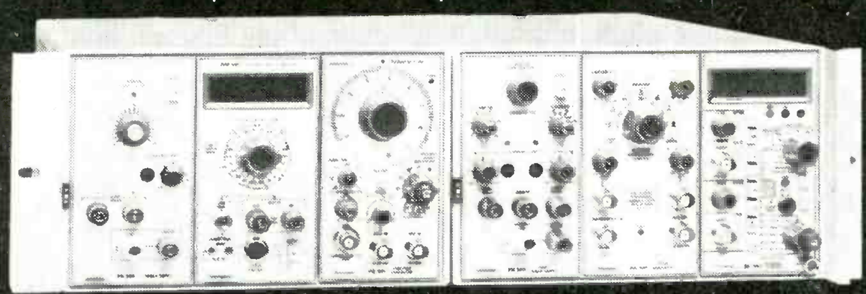
Test and measurement needs flexibility; the TM 500 SERIES has got it-and lots to spare

The TM 500 Series Test and Measurement System is organised around two types of mainframe, the TM 501 and the TM 503.

Portable / Flexible Reduced bench clutter



The TM 503 is a three-compartment mainframe accepting **any combination of three** of the 500-Series plug-in modules. The plug-in module combination significantly saves bench space, and by using the intra-compartment interface featured in the TM 503, multi-function applications are readily obtained. The TM 503 incorporates a carrying handle and a tilt stand for convenient bench-top use. Size? Only 6 x 8.7 x 15.3 in.



Portable / Versatile

The TM 501 is a compact, easy-to-carry, single-compartment mainframe accepting any **one** of the 500-Series plug-in modules.

Flexible/Compact/ Room to grow

Cabinet-to-rackmount conversion kits enable either one or two TM 503 mainframes to become a rack installation, increasing still further the flexibility of the TM 500 Series concept. The **combination of three or six** of the 500-Series plug-ins, plus the 'mix-and-interface' facility, offers a variety of measurement capabilities.

Plug-in modules

A choice of 14 (and more to be announced) plug-in modules is available, covering Digital Counters, Digital Multimeters, Power Supplies and Generators. Each unit, front panel colour-coded for ready identification, offers **low cost per function.**

WW—083 FOR FURTHER DETAILS

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St. Fidelis Road, Erith, Kent. Tel. Erith 39121

WW—084 FOR FURTHER DETAILS

New Products

Waveform monitor

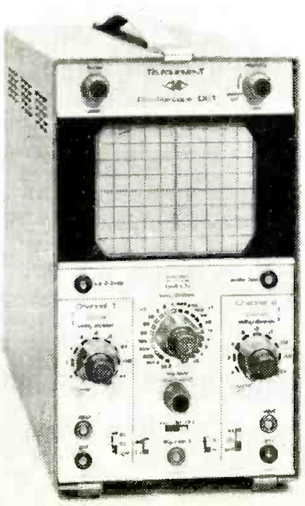
Rohde & Schwarz have designed the OKF waveform monitor for television measurements. Covering the 0 to 20MHz range, the OKF has three switch-selected isolated Y inputs, i.e., a low-impedance input ($Z = 75\Omega$), a high-impedance input ($Z_{in} = 1M\Omega//20pF$) and a bridging-filter input ($Z = 75\Omega$).

The high accuracy claimed for this instrument arises from its vertical magnification and shift facilities: picture signals can be displayed up to an equivalent height of 150mm, allowing measurement accuracy to within 0.5%. Other features include: d.c. restoration for composite colour video signals; noise-voltage measuring circuit for an equivalent display height of 500mm, with a wide Y-positioning range (measurement possible down to –60dB); linearity measuring circuit for 1 and 4.43MHz; individual display of the four PAL-interlaced fields of a composite colour video signal; and H delay for display of line or testline details and double triggering of the main sweep generator for excess-level signals. Aveley Electric Ltd, Roebuck Road, Chessington, Surrey KT9 1LP.

WW316 for further details

"Tallboy" oscilloscope

A new, low-cost oscilloscope which has been added to Telequipment's family of lightweight portables is called the D61,



and is a dual-trace 10MHz instrument developed for general purpose applications including TV servicing. Its all solid-state components, generally rugged construction and upright proportions are claimed to make the instrument ideal for field work.

Triggering, selection for TV line and frame displays, and selection of chopped or alternate modes are all automatically selected on the timebase on the D61, which also switches one vertical channel to the horizontal input for X–Y displays. Price £110. Tektronix U.K. Ltd, Beaverton House, 36-38 Coldharbour Lane, P.O. Box 69, Harpenden Herts.

WW321 for further details

H.F. drilling machine

Adcola Products Ltd has introduced a compact, high frequency p.c.b. drilling machine. Known as the Quick Star, the machine has been designed to fill the gap between expensive automatic p.c.b. machines and slow manually operated machines which often lack the precision of the automatics in control. Basically the Quick Star is intended for rectification of p.c.b. production work, small batch production, design and development laboratories, or as an ancillary machine for watchmakers, jewellers and dental mechanics.

It consists of an electro-mechanical guided, high frequency spindle providing infinitely variable drilling speeds from 10,000 to 50,000 r.p.m. The drilling unit is fed from a separate converter, which means that it can be conveniently positioned in the most suitable location while the converter module can be sited some distance away. The converter controls the drill speed and infinitely variable feed. Operation of the feed can be either by removable hand lever or foot switch.

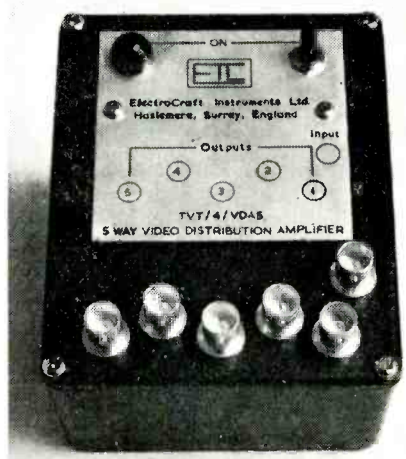
A special feature of the Quick Star lies in the visual drill positioning system, which includes a cross-wire projection onto a magnified circular viewing screen to provide a high degree of precision in control. This projection system incorporates two different types of light source — one built into the optical device and the other for use with an alternative enlarged magnifier lens. The selection of light source is controlled by a switch on the rear of drill section.

The drill spindle will accept a range of tungsten carbide drills from 0.2 to 2.00mm and the stroke height is adjustable from 10mm. The drilling area is 180 sq mm. The total cost of the drilling machine, converter module with accessories is less than £600. Optional extras include an electronic impulse counter, the enlarged magnifier lens and a larger base to increase the drill stand area to 320mm × 400mm. Further details of the machine are available from Adcola Products Ltd, Adcola House, Gauden Road, London SW4 6LH.

WW320 for further details

Video distribution amplifier

Electrocraft instruments announce a self-contained video distribution amplifier, providing five or ten independent signal outputs at 75 Ω from one input. The models TVT/4/VDA 5-10 are designed to handle monochrome or colour video signals for a wide range of industrial and



commercial c.c.t.v. applications. Housed in die-cast boxes, the video distribution amplifiers are of rugged construction and designed for continuous operation under arduous conditions.

Price: 5 way £38.00
10 way £58.00

Dimensions: 5 way 4.75 × 3.75 × 2.75in
10 way 6.75 × 4.75 × 2.75in

Electrocraft Instruments Ltd, Liss Mill, Mill Road, Liss, Hants.

WW310 for further details

D.I.P. resistor network

The Helipot Series 899-40 Resnet d.i.p. network available from Beckman Instruments has been designed to provide the optimum termination resistance and threshold level for interfacing two Intel l.s.i. chips, the 1103 and the 3208A.

In order to use Intel 1103 – the basic memory element – in a computer it is necessary to interface the device with t.t.l. logic. This interface chip, the 3208A, requires a network of eight resistors for every six bits. The Helipot Model 899-40 Resnet d.i.p. provides six resistors of 600Ω each (R_3), and a voltage divider (R_1 and R_2) to supply the 150mV threshold level required for the 3208A.

For the standard Intel 1103, operating with a minimum read cycle of 480ns and a minimum write cycle of 580ns, the R_3 terminating resistors have the optimum 600Ω value.

The R_2-R_1 network provides the 150mV threshold voltage to the 3208A: $R_1 = 2780\Omega$ and $R_2 = 87.4\Omega$. Using these resistor values and the $\pm 5\%$ variation in 5V power supply regulation, the threshold voltage is 150mV $\pm$ 13.0mV.

Among the advantages claimed for the use of the network are: total compatibility with automatic insertion equipment; reduction of p.c. board area; and reduction of assembled board costs. Beckman Instruments Ltd (Components International), Glenrothes, Fife.

WW314 for further details

Thick film precision resistors

Technograph & Telegraph are offering precision resistor networks, manufactured by thick film methods, giving a stability better than 0.15% after 5,000 hours at 125°C. The temperature coefficients for mid-range resistor values are below 50 p.p.m./°C and temperature coefficient of resistance tracking of 15 p.p.m./°C can be achieved. These custom designed networks can be supplied with resistor tolerances of $\pm$0.5% absolute, or resistors matched to $\pm$0.25%. Packages may be "on edge" or "dual-in-line" as required by the customer. Technograph & Telegraph Ltd, Easthampstead Road, Bracknell, Berks. RG12 1NW.

WW317 for further details

High frequency filter

Kinetic Technology announces an extension of the frequency range of the FS-30 high frequency filter. Utilization of multi-loop negative feedback allows simultaneous highpass, lowpass and bandpass transfer functions. Independent tuning of gain, centre frequency, and Q is accomplished with the addition of external resistors. Qs as high as 1000 can be obtained at frequencies below 100kHz. The FS-30 is packaged in a 14-pin d.i.p. configuration measuring 1.5 by 0.5in. Operating temperature range is 0 to 70°C and power consumption is 156 to 225mW at $\pm$15 to $\pm$20V. F.O.B. price $40.00 each in quantities of 100 and delivery is from stock. Kinetic Technology, Inc., 3393 De La Cruz Boulevard, Santa Clara, California 95050, U.S.A.

WW311 for further details

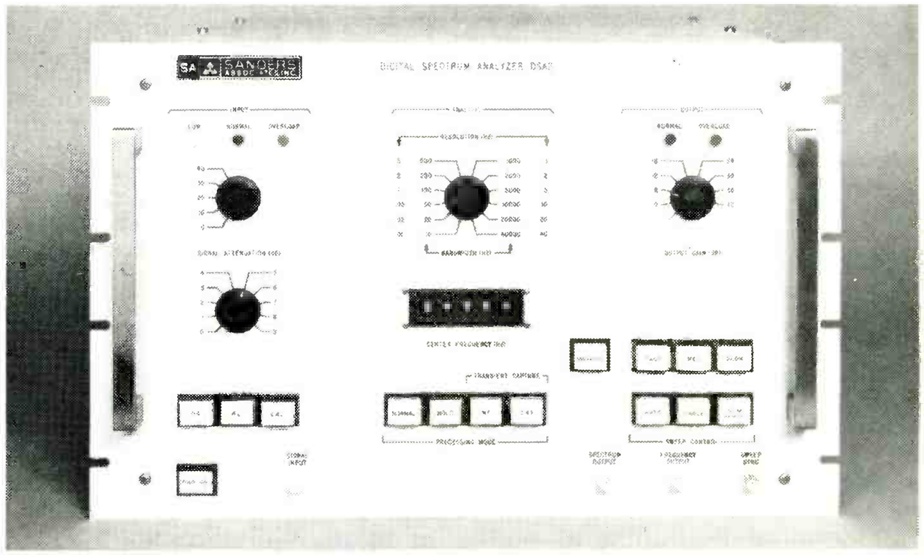
1024-line real time spectrum analyser

A high resolution, real-time digital spectrum analyzer that provides 1024-line spectral analysis over a centre frequency range of d.c. to 40kHz is available from Sanders Associates for use in radar and sonar signal processing, acoustic spectrum level measurement, and noise and vibration analysis.

Designated DSA–2004, it features all-digital circuitry for translation, filtering, Fourier analysis, post processing and storage. The unit, which has modular construction and built-in self-test capability, provides resolutions selectable from 0.01Hz to 40Hz and an analysis bandwidth of 10Hz to 40Hz.

The DSA-2004, with an internal simultaneous multi-channel processing capability, provides linear and logarithmic outputs for electrographic recorder, X-Y chart recorder, c.r.t. display and oscilloscope. Digital Communications, Sanders Associates, Inc., 95 Canal Street, Nashua, New Hampshire 03060, U.S.A.

WW319 for further details



Programmable distortion analyser

A new distortion analyser/a.c. voltmeter, the Hewlett Packard model 334A–H25, has all the capabilities of the standard Model 334A plus programmability of all functions, ranges and settings. Remote control is by parallel b.c.d. t.t.l. logic. A d.c. output and an interrogation circuit have been added so that an external controller can determine the status of the instrument during measurements. The Model 334A–H25 can be manually controlled with back-lighted front panel push-buttons.

As a distortion analyser, the instrument measures total harmonic distortion from 0.1% to 100% full scale in seven ranges. The fundamental frequency range for distortion measurements is from 10Hz to 100kHz; harmonics are indicated up to 1MHz. Frequency resolution is 3 digits over the full frequency range. As an r.m.s. calibrated voltmeter, the Model 334A-H25 measures input levels from 0.3mV r.m.s. to 300V r.m.s. full scale in thirteen meter ranges. The frequency range for voltage measurements is from 10Hz to 1MHz. Local or remote operation can be selected. In the "local" mode, the Model 334A–H25 is operated as a bench instrument using front-panel pushbutton switches. In "remote", it accepts parallel 8–4–2–1 b.c.d. coded instructions applied to the remote control lines. Internal storage is not provided. Remote control lines use standard t.t.l. logic levels. Provision is made for changing from high to low assertion states. A total of 34 lines is required for complete remote control. The Model 334A–H25 is priced at £1,732, excluding duty. Hewlett-Packard Ltd., 224 Bath Road, Slough, Bucks. SL1 4DS.

WW307 for further details

Solid State Devices

Signetics announce three 8-input digital t.t.l. multiplexers using Schottky technology. The 82S30 incorporates an "inhibit" input which, when low, allows the one-of-eight inputs selected by the address to appear on the "f" output and in complement on the "f̄" output. The 82S31 is a variant of the 82S30 that provides open collector output "f̄" for expansion of input terms. The 82S32 is similar to the 82S30 except for the effect of the "inhibit" input on the "f̄" output. With the "inhibit" low, the selected input appears at the "f" output and in complement on the "f̄" output. With the "inhibit" input high both the "f" and the "f̄" outputs are unconditionally low.

Also from Signetics is an i.c. f.m. detector and limiter which uses linear gating techniques and is designated type ULN 2111. Only a single coil is required with this device which has a frequency range from 5kHz to 50MHz. Outputs of 0.6V with a total distortion of less than 1% and a limiting threshold voltage of 400 μ V r.m.s. are typical. Price is £0.68 for 100-up quantities in the d.i.l. plastic package.

Finally there is a dual amplifier used as an interface between m.o.s. and t.t.l. devices. This amplifier, designated the 8T25, is manufactured in an 8-pin miniature d.i.l. package. Signetics International Corporation, Yeoman House, 63 Croydon Road, London S.E.20.

WW326 digital multiplexer
WW327 f.m. detector/limiter
WW328 dual amplifier

Feldon Audio, known more for professional sound studio equipment, announce they are to distribute a monolithic operational amplifier, the MCI 2001. This device was made specially for use in the MCI range of mixing consoles and thus has unusual characteristics. The input has a balanced open loop input impedance of better than 250k Ω, making the device suitable for summing or bridging applications, and a low output impedance capable of driving several 600 Ω loads. Open loop gain is 90dB and the maximum 20Hz to 20kHz closed loop gain is 50dB. Output capability is +24dBm into 600 Ω and distortion at a closed loop gain of 20dB is 0.004% t.h.d. at 1kHz and 0.05% t.h.d. at 20kHz. These measurements were made at an output level of +23dBm. Equivalent noise is −112dB. Feldon Audio Ltd, 126 Great Portland Street, London W1N 5PH.

WW329 for further details

Three devices are announced by Burr Brown International. The first is an i.c., f.e.t. device, type 3542J, and features a maximum voltage drift of ±50 V/C and a guaranteed input bias current of −25pA. Hermetically sealed in a TO–99 package, the unit is pin compatible with 741 type operational amplifiers. Minimum d.c. voltage gain is 88dB, full power frequency response is 8kHz and the slew rate is 0.5V/μs. Both output short circuit and input-to-supply voltage protection are provided. Output is ±10V at ±10mA.

The second device is a pulse modulation analogue multiplier with an accuracy to 0.2% (20mV). External trimming will improve the accuracy to 0.1% (10mV). The absolute maximum input ratings are ±30V and the rated output is ±10V at 5mA minimum. Output noise from d.c. to 10kHz is 1mV r.m.s. and the gain error versus temperature is 0.01%/°C. The device is designated model 4200 and can be used for flow rate and power calculations or, by change of pin connection, the 4200 can be used to divide and to take the square root.

Finally, this company introduces a high speed 8–channel multiplexer with an internal channel address decoder, type MPM–8S. Capable of expansion to 256 channels in a multi-tiered matrix, the device accepts ±10V analogue signals and binary coded t.t.l. compatible channel address information. Throughout, speeds of up to 250kHz are feasible with crosstalk of −115dB with a 1kHz full-scale sine wave applied to all the "off" channels. Burr Brown International Ltd, 25A King Street, Watford WD1 8BT, Herts.

WW330 f.e.t. op-amp
WW331 analogue multiplier
WW332 8-channel analogue multiplexer

A high speed r.a.m. (randome access memory) and three monolithic arrays of silicon planar photodiodes are now available from Mullard. The r.a.m., type GYQ131, is a 1024-bit device functionally equivalent to the GYQ101 r.a.m. as well as the 1103 type of device. It offers, however, greater operating speed and dynamic operation with a supply voltage of 19V.

The diode arrays F758 and F759 have 12 and 16 photodiodes respectively arranged in a strip with a pitch of 1.25mm. Each diode has an active area of 2.09mm^2, operates with a reverse voltage of 15V and has a typical sensitivity of 14nA/lux. The third array, type F568, contains 12 photodiodes on a pitch of 2.05mm. Each diode operates with a reverse voltage of 1V to give a typical sensitivity of 40nA/lux. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

WW333 high speed r.a.m.
WW334 photodiode arrays

Teledyne Philbrick have introduced the model 1427 f.e.t. operational amplifier and the model 4853 high speed sample-hold amplifier. The performance features of the 1427 include a 7MHz bandwidth, 900ns settling time to 0.01% and an initial offset voltage of ±500 μ V. Offset voltage drift is 50 V/°C or a selected version, the 142701, is available with an offset drift of 25 μ V/°C.

The 4853 is a high speed 0.01% sample-hold amplifier with an extremely low aperture time of ±1ns and a low feed-through of 1mV maximum for a 20V step. Acquisition time is less than 1 μ s to 0.01%. Teledyne Philbrick, Allied Drive at Route 128, Dedham, Massachusetts 02026, U.A.S.

WW335 f.e.t. operational amplifier
WW336 sample-hold amplifier

G.D.S. (Marketing) who supply products from Harris Semiconductor and Motorola, among others, announce the availability of new devices from both these companies. From Harris come two devices, a 1024-bit p.r.o.m. (programmable read-only memory) and a four-channel operational amplifier.

The memory, which is high speed and fully decoded, is designated the HPROM-1024A. Access time is typically 50ns and a maximum of 70ns. Address time is 20ns. Supply is from a single 5V source and the device is t.t.l./d.t.l. compatible. As supplied all bits store a logical "1" and can be selectively programmed for a logical "0". The HPROM-1024A has an open collector output, but a second version, the HPROM-1024, has a third high impedance state output which allows the device to work in a "wired-OR" configuration. Both devices are supplied in 16 pin d.i.l. packages.

The four-channel operational amplifier, type HAO2405, combines the function of an analogue switch and a high performance amplifier. Four pre-amplifier sections, one of which is selected through d.t.l./t.t.l. compatible inputs to be connected to the output, are contained within the 16 pin d.i.l. package. The unusual configuration of this device, which Harris call the PRAM(!) — programmable analogue module — makes it suitable for use as a programmable attenuator, multivibrator, active filters, four-channel comparator and signal selection/multiplexer.

Also from G.D.S. are the Motorola c.m.o.s. divide by "n" 4-bit counters. These are the MC14522L and the MC14526CL, both of which are programmable devices. The first is a b.c.d. counter and the second a binary counter, and both devices can be operated from supply rails from 3 to 16V. The counters are supplied in 16 pin d.i.l. packages at a 100-up cost of £3.096. GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.

WW337 1024-bit p.r.o.m.
WW338 4 channel p.r.a.m.
WW339 b.c.d. counter
WW340 binary counter

May Meetings

Tickets are required for some meetings: readers are advised therefore to communicate with the society concerned

LONDON

1st. IEE — "Lord Kelvin and his measuring instruments" by J. T. Lloyd at 17.30 at Savoy Pl., WC2.

2nd. IEE — "Seeing in the dark" by Dr. P. Schagen, Dr. A. J. Goss, E. D. Hendry and R. D. Nixon at 16.00 at Savoy Pl., WC2.

2nd. IEE/IERE — Colloquium on "Electro-mechanical problems of computer systems" at 17.30 at Savoy Pl., WC2.

3rd. IEE — Discussion on "The interface problem: Radio centre to A.F.C.S." at 17.30 at Savoy Pl., WC2.

3rd. IEE Grads — "Careers in control and automation" by M. G. Shortland at 18.30 at Savoy Pl., WC2.

4th. IEE — Colloquium on "The automation of railway systems in the '70s" at 17.30 at Savoy Pl., WC2.

7th. IEE — "Digital sound recording" by F. A. Bellis at 17.30 at Savoy Pl., WC2.

9th. IEE — "A matter of fact: The technical possibility of a broadcast information service" by P. Rainger at 17.30 at Savoy Pl., WC2.

9th. IERE — "Preparing engineers and managers for design specification" by Prof. D. Pilfold at 18.00 at 9 Bedford Sq., WC1.

10th. IEE — Discussion on "Engineering graduates: Great expectations or hard times?" at 17.30 at Savoy Pl., WC2.

11th. IEE/IERE — Colloquium on "Recent developments in self-organising and heuristic computers" at 14.30 at Savoy Pl., WC2.

11th. IEE — "Electronic aids in archaeology" by Dr. E. T. Hall at 17.30 at Savoy Pl., WC2.

11th. BAS/I.Phys. — "Developments in high fidelity systems" at I.Mech.E., 1 Birdcage Walk SW1.

14th. IEE — "Non-linear systems analysis by multi-dimensional transform methods" by Prof. H. A. Barker at 17.30 at Savoy Pl., WC2.

14th. IEE Grads. — "Understanding lasers" by M. Kear and "Transmission line impedance measurement at microwave frequencies" by J. W. Gould at 18.30 at Savoy Pl., WC2.

15th. IEE/IERE — Colloquium on "Electrical connectors — applications and reliability" at 14.00 at 9 Bedford Sq., WC1.

15th. AES — "Physics and the perception of musical sounds", by Prof. C. A. Taylor at 19.15 at the IEE, Savoy Pl., WC2.

16th. IEE — "A 6GHz radio delay digital transmission system" by E. S. Doe and H. D. Hyamson at 17.30 at Savoy Pl., WC2.

16th. IERE — "Meteorological telecommunications systems engineering" by C. E. Goodison at 18.00 at 9 Bedford Sq., WC1:

23rd. R.I. Navigation — "The commercial and political implications of a global satellite navigation system" by T. M. B. Wright at 17.00 at The Royal Institution of Naval Architects, 10 Upper Belgrave St., SW1.

23rd. IERE — "Adaptive equalization" by Dr. A. P. Clark at 18.00 at 9 Bedford Sq., WC1.

31st. RTS — "Television and satellites for European education — social, political and industrial implications" by Dr J. L. Jankovich at 19.00 at I.B.A., 70 Brompton Road, SW3.

MANCHESTER

1st. IEE — "Investment approval in the Post Office" by F. Broadhurst at 18.15 at the Renold Building, U.M.I.S.T.

3rd. IERE — "Facsimile — a review" by J. Malster and M. J. Bowden at 18.45 at the Renold Building, U.M.I.S.T.

NEWCASTLE UPON TYNE

7th. IEE — "Marine electronics reliability" by M. G. Miller at 18.30 at the University, Room M421.

SHEFFIELD

2nd. IEE — "New thoughts on sleep and dreams" by Dr. C. R. Evans at 18.30 at Telephone House, Charter Sq.

STAFFORD

7th. IEE — "Instrumentation & electrical engineering in vehicle research and development" by T. R. Aston at 19.00 at N. Staffs Polytechnic, Beaconside.

9th. IEE Grads — "Quadraphonics" by Dr. K. Barker at 19.30 at North Staffordshire Polytechnic.

Announcements

A short course **"Modern Instrumentation and Data Systems"** is to be held at Lanchester Polytechnic, Priory Street, Coventry CV1 5FB on each Thursday of May. It is expected that those attending will be users of electronic instrumentation systems.

The subject of a residential vacation school to be held at the University of Birmingham from 16th to 21st September 1974 is **"Basic concepts in modern control theory"**. The school is being organized by the Control & Automation Division of the Institution of Electrical Engineers and is intended to be of interest to control systems engineers and to teachers in this sector of higher education. Further details from the Secretary, I.E.E., Savoy Place, London WC2R 0BL, quoting the reference LS(CA).

A one-week residential vacation school intended for practising engineers, scientists and teachers, who need have no previous knowledge of, but are interested in, the **fundamentals of logic circuit design** is being organized by the Electronics Division of the Institution of Electrical Engineers. The school "Logic design — for digital systems" will be held at the University of Kent in Canterbury from 23rd to 28th September 1973. Further details available from Senior Divisional Secretary (Electronics), IEE, Savoy Place, London WC2R 0BL.

The closing date for the receipt of applications for consideration for the award of **scholarships** in 1973 from the Council of the Institution of Electrical Engineers is 1st May. Awards include grants to deserving students to assist them in obtaining professional qualifications and grants to assist postgraduate students (IEE members only) with advanced study or research. Particulars from the Education and Training Officer, IEE, Savoy Place, London WC2R 0BL.

New Industrial Products for Europe — an E.E.C. trade-boosting product journal — is to be launched inSeptember, by IPC Industrial Press. To be published in each of the six peak European buying months (Sept.–Nov. and Mar.–May) the journal will be circulated to 28,000 senior executives of the larger companies within the Common Market, excluding the U.K. and Eire. Further information can be obtained from the Publishing Director, IPC Industrial Press Ltd. 33/39 Bowling Green Lane, London EC1R 0NE.

Following an agreement concluded with Honeywell Ltd, the company Wayne Kerr, Tolworth Close, Tolworth, Surbiton, Surrey KT6 7ER, is now world-wide distributor for "Swift" **digital testers.** These instruments are complementary to the Wayne Kerr "Testmatic" range of analogue testers.

The computer peripheral company **Pertec International** is now at 10 Portman Road, Battle Farm Industrial Estate, Reading.

Lyons Instruments Ltd, Hoddesdon, Herts. have announced their appointment as U.K. distributors for Kinetic Technology Inc., Santa Clara, California, manufacturers of a range of standard, universal, **hybrid active filters.**

Potter Data Products Ltd. Station House, Harrow Road, Wembley, Middx, is to market the U.S.A. company Scan-Optics' 20/20 and 20/10 ranges of **optical character readers.**

The contribution of Plessey Radar, Addlestone, Surrey, to the **Eurocontrol Upper Airspace Centre** at Karlsruhe, Germany, covers the supply of the complete operator input system and over 140 console operation positions for the centre. The contract is valued at £1.25M.

Studio Electronics, P.O. Box 18, Harlow, Essex CM18 6SH, design, build, claibrate and maintain specialist electronic and communications equipment, and will quote for this service, which includes alignment for the Nelson-Jones f.m. tuner and supply of other kits from *W.W.* articles.

Coutant Electronics Ltd, 3 Trafford Road, Reading, RG1 8JR, and APT Electronics are to undergo re-organization and integration of the two companies' production, marketing, financing and other services. Coutant will handle standard **power supply products** while APT will develop and produce custom units.

Blueline Electronic Component Services, Refuge House, River Front, Enfield, Middlesex, has signed five new franchises for AB Electronic Components, AEI Semiconductors, Airscrew Fans, ERG and Burgess, and has also opened a branch office in Manchester. Rotary and pushbutton **switches** and circular connectors from AB Electronic Components, microswitches and pushbutton switches from Burgess and d.i.l. switches from ERG are now included in the Blueline product range.

A new company has been formed to combine the manufacturing facilities of Semra (Electronics) Ltd and Benney Electronics Ltd. Trading under the name Semra-Benney (Electronics) Ltd, the company will operate from a factory situated at Chandler's Ford, Hampshire SO5 3ZU. Products and services offered by the company include a range of **nuclear physics instrumentation** and hardware in both the NIM and CAMAC systems, stabilized modular power supplies and specialist design and packaging facilities.

A new company known as International Aeradio Consultancy Services Ltd. based at Southall, Middlesex, has been formed to segregate International Aeradio's technical consultancy work in **aviation and communications** fom its operational and other activities. The new company, will undertake a wide range of consultancy work.

The Society of Relay Engineers has changed its name to the **Society of Cable Television Engineers,** 10 Avenue Road, Dorridge, Solihull, Warwickshire. The Society's journal, *The Relay Engineer,* will now appear as *Cable Television Engineering.*

Sonax Electronics is now part of the new Chaterville group of companies which incorporates Quadrasonics who produce a range of **four-channel audio systems.** The group is a CBS SQ licensee. Quadrasonics are situated at Spencer House, Brettenham Road, Edmonton, London N.18.

Pye TVT Ltd, Coldhams Lane, Cambridge, has received a contract valued at more than £2,100,000 from the Ministry of Culture and Information of the South Korean Government for a **colour television service** for the Korean Broadcasting System.

Literature Received

For further information on any item include the WW number on the reader reply card

ACTIVE DEVICES

Two low-power helium-neon encapsulated plasma-tube lasers, providing minimum unpolarized power outputs of 1.0 and 2.0mW at a wavelength of 633 nm in a beam diameter of 0.725mm, are described in a leaflet from Hughes Electron Dynamics Division, 3100 W. Lomita Blvd., Torrance, California 90509 ....WW401

"Solid State Converter type Vib 24V/9A", which is an assembly of the active elements of a d.c. to d.c. power supply unit designed to be a direct replacement for the conventional electromagnetic vibrator units, is the subject of a brochure from Industrial Instruments Ltd, Stanley Road, Bromley, Kent BR2 9JF WW402

A catalogue with specifications of over 600 different types of field effect transistor covering n- and p-channel junction types, n- and p-channel enhancement mode types, dual n-channel junction and dual p-channel enhancement mode devices has been received from Tranchant Electronics (U.K.) Ltd, Tranchant House, 100a High Street, Hampton, Middlesex TW12 2ST WW403

A data sheet dealing with the 1034 and 103401 general purpose, medium power output, operational amplifiers providing voltage outputs of ± 20V with peak current output of up to ± 22mA and an open-loop gain and unity gain bandwidth of 100,000 and 1MHz minimum respectively, has been received from Teledyne Philbrick, Allied Drive at Route 128, Dedham, Massachusetts 02026, U.S.A. WW404

A range of high current (785A r.m.s.) "Hockey Puk Power Thyristors" capable of single cycle surge currents of over 9,000A peak at reverse voltages of between 50 and 600V peak and available in either ceramic case style (500PA series) or plastic encapsulation (501PA series) are detailed in bulletin E2573 from International Rectifier, Hurst Green, Oxted, Surrey WW405

Data sheets on photo-sensitive integrated circuits available from Integrated Photomatrix Ltd, The Grove Trading Estate, Dorchester, Dorset, include:
PX102 — light level to frequency converter containing a planar light sensor with amplification and triggered pulse generator claiming a typical linearity of $\pm 2\%$ WW406
PX117 — 9-channel tape reading array constructed of 0.100in spaced photo detectors and threshold switches........WW407
PX129 — a family of photo diodes mounted with analogue amplification having a choice of detection bandwidths of up to 400kHz allowing selection of optimum response time or optical sensitivity for specific applications WW408

PASSIVE DEVICES

A colourful leaflet giving a complete technical description of "Series 11" illuminated and "Series 21" non-illuminated miniature push buttons, signal lights and accessories is available from Highland Electronics Ltd, 33-41 Dallington Street, London EC1V 0BD WW409

Miniature compression load-cell type C2M1 and an adaptor for converting into miniature tension load-cell type U2M1 with standard capacities of 100, 200, 500, 1000, 2000 and 5000lb over a compensated temperature range of -9°C to $+46$°C is the subject of a brochure from Guest International Ltd. Control and Instrumentation Division, Redlands, Marlpitt Lane, Coulsdon, Surrey CR3 2HT WW410

Data sheets describing multi-octave bandwidth transmission line directional couplers types BD1040 (10dB coupling, 40dB directivity, 2-50MHz), BD2025 (20dB coupling, 25dB directivity, 10-250MHz), BD3020 (30dB coupling, 20dB directivity, 5-500MHz), NHP30B four port 180° hybrid (30dB isolation, 2-32MHz) and some similarly specified miniature components mounted in TO-5 packages are available from Tony Chapman Electronics Ltd, 3 Cecil Court, London Road, Enfield, Middlesex WW411

A wide range of double-ridge waveguide components manufactured by Microwave Research Corporation of America covers waveguide to coaxial transformers in the range 1.0 to 38GHz, waveguide terminations and double-ridge to rectangular waveguide transitions over the range 3.5 to 16GHz: these are described in data sheets from Suvicon Ltd, Hagley House, Hagley Road, Edgbaston, Birmingham B16 8QW WW412

Copies of catalogue No. 1470 which deals with the "Surefire" range of compatible and co-firable resistor, conductor and dielectric paste materials for use in the manufacture of hybrid and thick-film integrated circuits, are available from Johnson Matthey Metals Ltd, 81 Hatton Garden, London EC1P 1AE WW413

Cyclic timer type TCP2 which comprises an a.c. or d.c. motor driven shaft with between 2 and 24 independently adjustable cams, each operating a separate replaceable s.p.d.t. switch rated at 250V a.c. at 5A, is the subject of a leaflet from Tempatron Ltd, 5 Loverock Road, Battle Farm Estate, Reading, Berks WW414

Catalogue H/201 giving technical details and performance figures of tangential and axial air blowers, induced ventilation units and a range of frilec fans and trays suitable for a variety of cooling applications, has been received from Imhof-Bedco Ltd, Ashley Works, Ashley Road, Uxbridge, Middlesex UB8 2SQ WW415

A range of precision d.c. motors, suitable for servo systems and instrumentation, offering high power-to-volume ratios (0.2W/cm^3), high efficiencies (57-82%), fast response times (mechanical time constant from 19ms) and low starting voltages (100mV typ.), is described in a brochure from Portescap U.K. Ltd, 204 Elgar Road, Reading, RG2 0DD WW416

A new range of five base mounting open fuseholders accepting either 1in x $\frac{1}{4}$in or $1\frac{1}{4}$in x $\frac{1}{4}$in fuses and consisting of a twin-fuse model and two single-fuse models rated at 13A, 250V, and two single-fuse models rated at 5A, 250V is the subject of a leaflet from A. F. Bulgin and Co. Ltd, Bye-pass Road, Barking, Essex WW417

A catalogue describing the selection of general and special purpose soldering irons, including sophisticated electronic temperature controlled irons, thermal wire strippers and numerous associated tools is available from Light Soldering Developments Ltd, 28 Sydenham Road, Croydon CR9 2LL........WW418

Lists of components and materials useful to the electronics or audio enthusiast for home construction, experiments and servicing are available from Chromasonic Electronics, 56 Fortis Green Road, London N10 3HN WW419

A catalogue with technical information and data on the range of aerials and accessories for telecommunication applications such as point-to-point radio links, television links, satellite tracking, communications channel interference elimination, ground-to-air communication, missile tracking and telemetry is available from J. Beam Engineering Ltd, Rothersthorpe Crescent, Northampton WW420

EQUIPMENT

The "Venture multimeter range" are portable moving-coil instruments, taut ligament suspended. "Multimeter 1" is primarily designed for electrical engineering where high voltage and high current measurements are needed. "Multimeter 3" is a general purpose instrument with a.c. and d.c. ranges from 1kV to 100mV and 10A to 30A. "Multimeter 4", intended for electronic engineering, has sensitivities of 100k Ω/V on d.c. and 20k Ω/V on a.c. Smith Industries Ltd, Industrial Instrument Division, Waterloo Road, Cricklewood, London NW2 7UR WW421

A 72-page catalogue covering a wide range of electronic measuring and test equipment used in radar, TV and radio transmission and data distribution has been received from Magnetic AB, Box 20036, S-161 20 Bromma 20, Sweden. WW422

Brochure HP7109 is available discussing resonant a.c. dielectric testing using both series and parallel resonant techniques, together with explanation and comparison with d.c. and v.l.f. methods, using equipment manufactured by Hipotronics Inc., Brewster, N.Y.10509, U.S.A. WW423

A booklet has been received, describing a "Modulator Automated System To Identify Friend from Foe" (MASTIFF), which is an access control system developed to overcome the problem of maintaining security in areas where there is a large volume or considerable movement of personnel, from Lewis Security Systems Ltd, 9 The Crescent, Leatherhead, Surrey. WW424

APPLICATION NOTES

A six-page application note, AN-6054 "Triac Power Controls for Three Phase Systems" lists basic design rules, describes an integrated circuit zero voltage triac triggering switch and details methods of isolating the d.c. logic circuitry used in three-phase power control systems, is available from RCA Ltd, Solid State Europe, Sunbury-on-Thames, Middlesex. WW425

"F.e.ts as Analog Switches" is an application note dealing specifically with the basic factors affecting switch performance and some attention is given to switch-driver circuit design, overall switching characteristic and characterization of analogue switches at high frequencies. Siliconix Incorporated, 2201 Laurelwood Road, Santa Clara, California 95054 ....WW426

GENERAL INFORMATION

A pamphlet entitled "A simple Adding Machine", which is the latest in a series of educational projects in electronics produced by the Mullard Educational Service, describes a simple circuit using FJ series integrated circuits for the counter-decoder and gas-filled numerical indicator tubes for the display. Mullard Educational Service, Mullard Ltd, New Road, Mitcham, Surrey CR4 4XY WW427

"Aveley News" for January/March discusses TV relay-receiving systems in cassette construction, frequency response measurement using a differential method and a range of new electronic equipment from Rohde and Schwarz, Narda Microline, North Atlantic, Pacific Measurements, Eldorado and Lockheed Electronics. Aveley Electric Ltd, Roebuck Road, Chessington, Surrey KT9 1LP WW428

The 1973 Instrument Society of America's 36-page catalogue, describing over 200 current instrumentation publications and educational aids covering a considerable area of industry, science and technology, is available from Instrument Society of America, 400 Stanwix Street, Pittsburgh, Pa. 15222, U.S.A. WW429

Real and Imaginary

by "Vector"

Clunk, Click — and Boomps-a-Daisy!

In a way, it's rather nice to have the U.S.A. around on this planet because of the forthright way in which they jump in feet first and have a go. Like with colour TV for instance. Think of all the money and research effort poured into developing the N.T.S.C. system while we sat on the fence and waited until most of the bugs were out. Then — bingo! In with the PAL improvement and we were home and dry.

In fact, in that brash land of the free we have a ready-made Old Moore's Almanac telling us what's in store for us in five years' time. Naturally, it's not all cakes and ale; there are imports we could well do without.

All this was brought to mind by the news that the U.S. government is compelling all 1974 motor cars — sorry, autos — to be equipped with automatic seat-belt interlocks. This means, I gather, that when you clamber into the driving seat of your new Cadillac, the door has to be closed and your lap and shoulder belts have to be fastened or the starter motor won't operate. And that isn't all; any front-seat passengers (and there could be two in a Caddy) who weigh more than a modest 47 lb must likewise clunk-click before you can urge your horseless carriage forward.

Perhaps it's a sign of the times that the auto industry, which has always been electro-mechanically conscious, has turned to electronics (and integrated circuits in particular) to do this onerous chore. And it is onerous, make no mistake. Switches which will be concealed in (presumably) two doors, three sets of front seat-belts and pressure sensors in the seats all have to integrate to enable the starter switch to operate. Oh, yes — and there's a further requirement; the drain on the battery must be low — typically about 5mA — so as to give it a sporting chance during a cold start. The owner of a 1974 auto doing house-to-house calls all day in sub-zero temperatures is going to give his i.cs quite a going-over! I see that one big auto manufacturer is doing a belt-and-braces exercise by providing electro-mechanical back-up and I, for one, don't blame him.

I don't mean to imply by this that i.cs can't do the job. Of course they can. But neither the auto manufacturers nor the electronics people seem to have had much warning of Government intent; at any rate, no form of pilot scheme seems to have been possible, so it looks as if the inevitable bugs are going to move straight out onto the turnpike. And remembering that the big three — General Motors, Ford and Chrysler — alone reckon to turn out about 10 million autos per annum, that could add up to quite a lot of bugs.

The situation is one which is calculated to make any manufacturer wake up screaming in the night. We all know the feeling of exasperation generated when the car radio goes phut, but at least that circumstance doesn't strand you slap in the middle of the Arizona desert with only flies for company. But are the American i.c. moguls deterred? Not on your life! They've fallen over each other to get the juicy contracts that have been bandied around. Now, we all know from bitter experience something of the cloud-cuckoo-land of i.c. manufacture; promises are one thing; deliveries can be quite another. The American auto industry is well aware of this fact of life but there isn't much it can do about it except stroke its rabbit's foot. For it would seem that the i.c. boys have got it made. They press ahead with their circuits, "optimized for low current drain, high noise immunity and high voltage excursions", and the best of luck. If bugs develop in service, it's the auto manufacturers who will get the kicks from the customers. If deliveries don't materialize on time it's the auto manufacturers who will have to plead with the U.S. government for an extension of the time limit. So hold your noses, lads, and jump in feet first; the water's lovely!

The account I've read doesn't say, but presumably the specification applies also to foreign cars imported into the U.S.A., otherwise it makes rather a nonsense of the whole thing. If that's the case, I wonder what British car manufacturers are doing about it between strikes; and who's supplying the i.cs? As far as the British car home market is concerned, I suppose the Government over here will continue to pin its faith in Jimmy ("Clunk-Click") Saville *et. al.*, exhorting us to play the game and fasten our seat belts like decent chaps. Then, when the motoring public is decimated, the Department of the Environment will act; if the American scheme works it will use it and thereafter we shall be locked in by relatively fool-proof i.cs. If it doesn't we shall probably have to form a typically British queue for a Traffic Warden to do it manually with another one at our destination to release us. One or the other will happen in about five years' time.

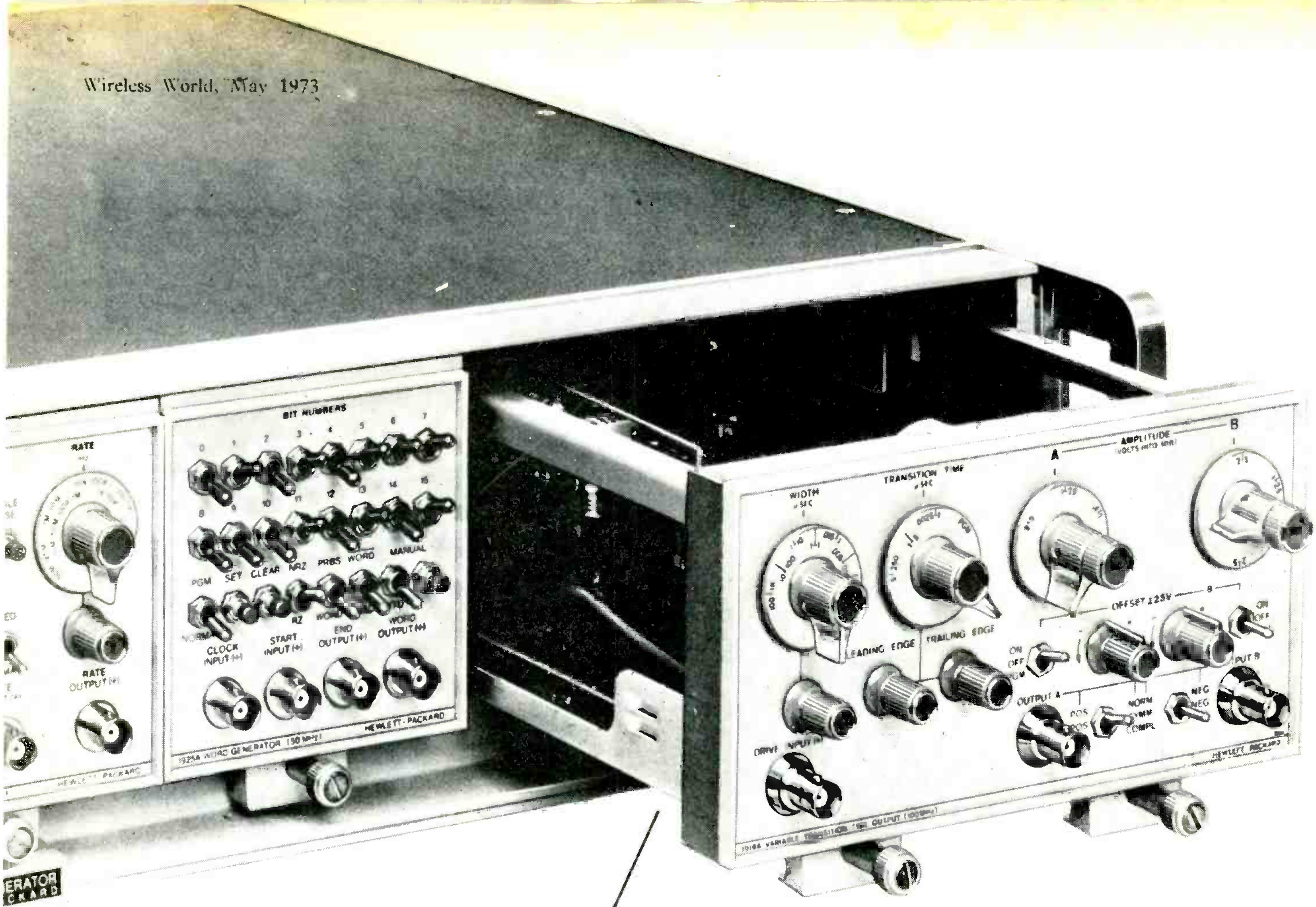
But back to the i.c. locking system. I only know what I've read but I'm sure there must be more to it than that. For one thing, any system that can be by-passed by a length of wire is suspect; and for another, it's doubly suspect if, as stated, the sequence of interlocks merely permits the starter solenoid to be energized. For, once the engine has been kicked into life the starter motor goes back to sleep, its job done; it would seem, therefore, that once the engine was running the safety belts could be unclicked and the doors opened at will. If you argue that no one's going to be so daft as all that, don't be too sure. It would be a kind of one-up-man-ship against the machine. And in any case what is there to prevent the owner keeping the seat-belts locked but hung up? Or will some additional sensor be incorporated which will discriminate between "full" and "empty"!

My guess — and it's only a guess — is that the interlock will be direct on to the ignition system and that the various by-passing possibilities will have been taken care of by extra circuitry (even more potential bugs?). Otherwise it seems to be a system of considerable complexity, to very little purpose. Perhaps an American correspondent can enlighten us?

There are, of course, two ways of approaching the problem of road safety. One is to go all out to devise a system in which accidents can't happen or, in realistic terms, in which they are rarities. The other approach is to accept that they are going to happen anyway and to devote the main research effort to protecting the vehicle's occupants as far as possible. Seat belts are in category two and undoubtedly do a grand job in instances where the impact isn't too severe; but when two cars, each doing 50 m.p.h., collide head on, I for one wouldn't fancy my chances with the best seat belt ever made.

I respectfully submit that the road accident problem will never be nailed until we face, for the first time, one inescapable fact, namely that the human brain's decision-taking and control capabilities and the human body's relative immunity to physical damage has evolved in relation to the speed at which his legs would carry him. Travel faster than this and your chances of walking away from an involuntary, instantaneous, full-stop become progressively less as the speed increases.

As for the human brain, it's far too sensitive to extraneous stimuli and too sluggish in its reactions when confronted with the unexpected in congested traffic conditions. Humiliating perhaps, but there it is. Sooner or later we shall have to admit it and give up some of our "freedoms". Airlines and railways are both subject to rigid control techniques and amateur drivers are not permitted; that's why accidents are so rare as to be front-page news. In the foreseeable future both systems will be completely automated and safer still. And those are the directions that road safety research should take. It will cost a heap of money and some sacrifice of pride, but to fiddle with anything less is patchwork stuff.



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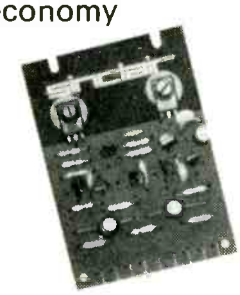
Now–the Z.50 Mk.2

with built-in automatic transient overload protection

When originally introduced, the Sinclair Z.50 proved how it was possible to design and produce a popularly priced modular power amplifier having characteristics to challenge the world's costliest amplifiers. Many thousands of Z.50's are now giving excellent service day in, day out. But we have also learned that constructors do not always use their Z.50's ideally. That is why we have introduced modifications whereby risk of damage through mis-use is greatly reduced and performance further enhanced. The Z.50 Mk.2 has improved thermal stability, more accurately regulated D.C. limiting to ensure more symetrical output voltage swing and clipping and still less distortion at lower power. Z.50 Mk.2 is compatible with all other Project 60 modules, and may be incorporated to advantage in existing systems. Eleven silicon epitaxial planar transistors are now used, two more than in the original Z.50; circuitry has been re-designed, making this versatile high performance amplifier better than ever.

with free manual
£5.48

Z.30 the power amplifier for quality and economy

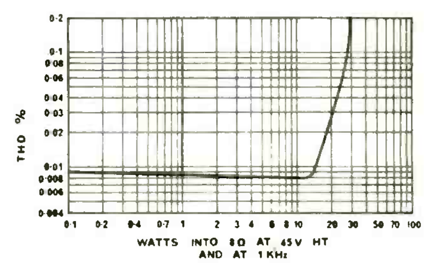


with free manual
£4.48

The Z.30 provides excellent facilities for the constructor requiring a high fidelity audio system of less power than that available from Z.50's. Using a power supply of 35 volts, Z.30 will deliver 15 watts RMS into 8 ohms, or 20 watts RMS into 3 ohms using 30 volts. Total harmonic distortion is a fantastically low 0.02% at 15 watts into 8 ohms with signal to noise ratio better than 70 dB unweighted. Input sensitivity 250mV into 100K ohms. Size 80 x 57 x 13 mm ($3\frac{1}{8}$ x $2\frac{1}{4}$ x $\frac{1}{2}$) Z.30, Z.50 and Z.50 MK.2 modules are compatible and interchangeable.

Brilliant new technical specifications

Input impedance 100 KΩ
Input (for 30w into 8Ω) 400mV
Signal to noise ratio, referred to full o/p at 30v HT 80dB or better
Distortion 0.02% up to 20W at 8Ω. See curve
Frequency response 10Hz to more than 200 KHz ±1dB
Max. supply voltage 45v (4Ω to 8Ω speakers) (50v 15Ω speakers only)
Min. supply voltage 9v
Load impedance – minimum : 4Ω at 45v HT
Load impedance – maximum : safe on open circuit



Guarantee

If, within 3 months of purchasing any product direct from Sinclair Radionics Ltd., you are dissatisfied with it, your money will be refunded at once. Many Sinclair appointed Stockists also offer this same guarantee in co-operation with Sinclair Radionics Ltd.

Each Project 60 module is tested before leaving our factory and is guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you, if it is returned within two years from the date of purchase. Outside this period of guarantee a small charge (typically £1.00) will be made. No charge is made for postage by surface mail. Air Mail is charged at cost.

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Typical Project 60 applications

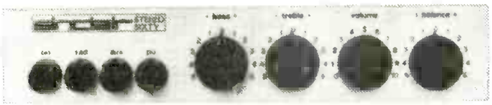
System	The Units to use	together with	Units cost
Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control, etc.	**£4.48**
Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control, etc.	**£9.45**
12W. RMS continuous sine wave stereo amp. for average needs	**2 x Z.30s, Stereo 60; PZ.5**	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	**£23.90**
25W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers	**2 x Z.30s, Stereo 60; PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
80W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60W. RMS into 8 ohms)	**2 x Z.50s, Stereo 60; PZ.8, mains transformer**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

F.M. Stereo Tuner **(£25)** & A.F.U. **(£5.98)** may be added as required.

WW—086 FOR FURTHER DETAILS

the world's most advanced high fidelity modules

Stereo 60 Pre-amp/control unit



Designed specifically for use on Project 60 systems, the Stereo 60 is equally suitable for use with any high quality power amplifier. Since silicon epitaxial planar transistors are used throughout, a really high signal-to-noise ratio and excellent tracking between channels is achieved. Input selection is by means of press buttons, with accurate equalisation on all input channels. The Stereo 60 is particularly easy to mount.

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ±1dB :20 to 25,000 Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE+12 to —12dB at 10KHz: BASS +12 to —12dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.

Built, tested and guaranteed. **£9.98**

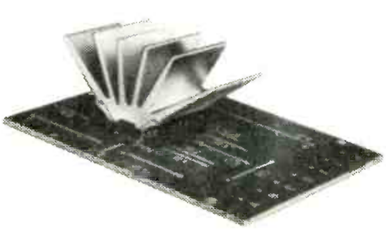
Project 60 Stereo F.M. Tuner

The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other advanced features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stero decoder and switchable squelch circuit for silent tuning between stations. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with most other high fidelity systems.

SPECIFICATIONS—Number of transistors: 16 plus 20 in I.C. **Tuning range:** 87.5 to 108MHz. **Sensitivity:** 7μV for lock-in over full deviation. **Squelch level:** Typically 20μV. **Signal to noise ratio:** >65dB. **Audio frequency response:** 10Hz – 15KHz (±1dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** 2μV. **Cross talk:** 40dB. **Output voltage:** 2 x 150mV R.M.S. maximum **Operating voltage:** 25–30VDC. **Indicators:** Stereo on; tuning. **Size:** 93 x 40 x 207mm.

Built and tested. Post free. **£25**

Super IC.12 Integrated circuit high fidelity amplifier



Having introduced Integrated Circuits to hi-fi constructors with the IC.10, the first time an IC had ever been made available for such purposes, we have followed it with an even more efficient version, the Super IC.12, a most exciting advance over our original unit. This needs very few external resistors and capacitors to make an astonishingly good high fidelity amplifier for use with pick-up, F.M. radio or small P.A. set up, etc. The free 40 page manual supplied, details many other applications which this remarkable IC. make possible. It is the equivalent of a 22 transistor circuit contained within a 16 lead DIL package, and the finned heat sink is sufficient for all requirements. The Super IC.12 is compatible with Project 60 modules which would be used with the Z.50 and Z.30 amplifiers. Complete with free manual and printed circuit board.

SPECIFICATIONS

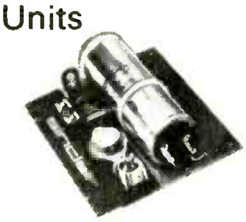
Output power: 6 watts RMS continuous (12 watts peak). 6–8Ω. **Frequency Response:** 5Hz to 100KHz±1dB. **Total Harmonic Distortion:** Less than 1%. (Typical 0·1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feedback. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22 x 45 x 28mm including pins and heat sink..

Manual available separately 15p post free.

With FREE printed circuit board and 40 page manual.

£2.98 Post free

Power Supply Units The new PZ.8 Mk.3



The most reliable power supply unit ever made available to constructors. Brilliant circuitry makes failure from over load and even direct shorting of the output impossible. This is due to an ingenious re-entrant current limiting principle which, as far as we know has never before been available in any comparable unit outside the most expensive laboratory equipment. Ripple and residual noise have been reduced to the point of almost total elimination. This is, of course, the perfect unit for Project 60 assemblies, particularly where the new Z.50 MK.2 amplifiers are used. Nominal working voltage – 45.

PZ.8 Mk.3—£7.98
(Mains transformer, if required) £5.98
PZ.5 30v. unstabilised
(not suitable for Project 60 tuner) £4.98
PZ.6 35v. stabilised
(not suitable for IC. 12) £7.98

Project 605

the easy way to buy and build Project 60 without soldering

Project 605 in one pack contains: one PZ.5, two Z.30's, one Stereo 60 and one Masterlink, which has input sockets and output components grouped on a single module and all necessary leads cut to length and fitted with clips to plug straight on to the modules thus eliminating all soldering.

Complete with comprehensive manual, post free **£29.95**
All you need for a superb 30 watt high fidelity stereo amplifier

Order form

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Business Reg. No. (England) 699483 Registered Office as above

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AC107	0·22	AD162	0·36½	BC148	0·11	BD136	0·44	BF185	0·33
AC113	0·22	AD161 &		BC149	0·13	BD137	0·49½	BF188	0·44
AC115	0·25½	AD162 (MP)		BC150	0·20	BD138	0·55	BF194	0·13
AC117K	0·22		0·60½	BC151	0·22	BD139	0·60½	BF195	0·13
AC122	0·13	ADT140	0·55	BC152	0·18½	BD140	0·66	BF196	0·15½
AC125	0·18½	AF114	0·26½	BC153	0·31	BD155	0·88	BF197	0·15½
AC126	0·18½	AF115	0·26½	BC154	0·33	BD175	0·66	BF200	0·44
AC127	0·18½	AF116	0·26½	BC157	0·20	BD176	0·66	BF222	1·04½
AC128	0·18½	AF117	0·26½	BC158	0·13	BD177	0·71½	BF257	0·49½
AC132	0·15½	AF118	0·38½	BC159	0·13	BD178	0·71½	BF258	0·66
AC134	0·15½	AF124	0·33	BC160	0·49½	BD179	0·77	BF259	0·93½
AC137	0·15½	AF125	0·27½	BC161	0·55	BD180	0·77	BF262	0·60½
AC141	0·15½	AF126	0·31	BC167	0·13	BD185	0·82½	BF263	0·60½
AC141K	0·18½	AF127	0·31	BC168	0·13	BD186	0·71½	BF270	0·38½
AC142	0·15½	AF139	0·33	BC169	0·13	BD187	0·77	BF271	0·33
AC142K	0·18½	AF178	0·33	BC170	0·13	BD188	0·77	BF272	0·38
AC151	0·16½	AF179	0·55	BC171	0·15½	BD189	0·98½	BF273	0·38½
AC154	0·22	AF180	0·55	BC172	0·15½	BD190	0·82½	BF274	0·38½
AC155	0·22	AF181	0·49½	BC173	0·15½	BD195	0·93½	BFW10	0·66
AC156	0·22	AF186	0·49½	BC174	0·15½	BD196	0·93½	BFX29	0·30
AC157	0·26½	AF239	0·40½	BC175	0·24	BD197	0·99	BFX84	0·24
AC165	0·22	AL102	0·71½	BC177	0·21	BD198	0·99	BFX85	0·33
AC166	0·22	AL103	0·71½	BC178	0·21	BD199	1·04½	BFX86	0·24
AC167	0·22	ASY26	0·27½	BC179	0·21	BD200	1·04½	BFX87	0·26½
AC168	0·26½	ASY27	0·33	BC180	0·26½	BD205	0·88	BFX88	0·24
AC169	0·15½	ASY28	0·27½	BC181	0·26½	BD206	0·88	BFY50	0·22
AC176	0·22	ASY29	0·27½	BC182	0·11	BD207	1·04½	BFY51	0·22
AC177	0·26½	ASY50	0·27½	BC182L	0·11	BD208	1·04½	BFY52	0·22
AC178	0·31	ASY51	0·27½	BC183	0·11	BDY20	1·10	BFY53	0·18½
AC179	0·31	ASY52	0·27½	BC183L	0·11	BF115	0·26½	BPX25	0·93½
AC180	0·18½	ASY54	0·27½	BC184	0·13	BF117	0·49½	BSX19	0·16½
AC180K	0·22	ASY55	0·27½	BC184L	0·13	BF118	0·77	BSX20	0·16½
AC181	0·18½	ASY56	0·27½	BC186	0·31	BF119	0·77	BSY25	0·16½
AC181K	0·22	ASY57	0·27½	BC187	0·31	BF121	0·49½	BSY26	0·16½
AC187	0·24	ASY58	0·27½	BC207	0·12	BF123	0·55	BSY27	0·16½
AC187K	0·22	ASZ21	0·44	BC208	0·12	BF125	0·49½	BSY28	0·16½
AC188	0·24	BC107	0·10	BC209	0·13	BF127	0·55	BSY29	0·16½
AC188K	0·22	BC108	0·10	BC212L	0·12	BF152	0·60½	BSY38	0·20
ACY17	0·27½	BC109	0·11	BC213L	0·12	BF153	0·49½	BSY39	0·20
ACY18	0·22	BC113	0·11	BC214L	0·15½	BF154	0·49½	BSY40	0·31
ACY19	0·22	BC114	0·16½	BC225	0·27½	BF155	0·77	BSY41	0·31
ACY20	0·22	BC115	0·16½	BC226	0·38½	BF156	0·53	BSY95	0·14
ACY21	0·22	BC116	0·16½	BCY30	0·26½	BF157	0·60½	BSY95A	0·14
ACY22	0·17½	BC117	0·16½	BCY30	0·26½	BF158	0·60½	Bu105	2·20
ACY27	0·19½	BC118	0·11	BCY31	0·28½	BF159	0·66	C111E	0·55
ACY28	0·21	BC119	0·33	BCY32	0·33	BF160	0·44	C400	0·33
ACY29	0·38½	BC120	0·88	BCY33	0·24	BF162	0·44	C407	0·27½
ACY30	0·31	BC125	0·13	BCY34	0·27½	BF163	0·44	C424	0·22
ACY31	0·31	BC126	0·20	BCY70	0·15½	BF164	0·44	C425	0·55
ACY34	0·23	BC132	0·13	BCY71	0·20	BF165	0·44	C426	0·38½
ACY35	0·23	BC134	0·20	BCY72	0·15½	BF167	0·24	C428	0·22
ACY36	0·31	BC135	0·13	BCZ10	0·22	BF173	0·24	C441	0·33
ACY40	0·18½	BC136	0·16½	BCZ11	0·27½	BF176	0·33½	C442	0·33
ACY41	0·19½	BC137	0·16½	BCX12	0·27½	BF177	0·38½	C444	0·38½
ACY44	0·38½	BC139	0·44	BD121	0·66	BF178	0·33	C450	0·24
AD130	0·42	BC140	0·33	BD123	0·71½	BF179	0·33	MAT00	10·21
AD140	0·53	BC141	0·33	BD124	0·66	BF180	0·33	MAT101	0·22
AD142	0·53	BC142	0·33	BD131	0·55	BF181	0·33	MAT120	0·21
AD143	0·43	BC143	0·33	BD132	0·66	BF182	0·44	MAT121	0·20
AD149	0·55	BC145	0·49½	BD133	0·71½	BF183	0·44	MPF102	0·46
AD161	0·36½	BC147	0·11	BD135	0·44	BF184	0·27½	MPF104	0·40½

MPF105	0·40½	2G344	0·20	2N2217	0·24	2N3053	0·18½	2N4059	0·11
OC19	0·38½	2G345	0·17½	2N2218	0·22	2N3054	0·50½	2N4060	0·13
OC20	0·69½	2G371	0·17½	2N2219	0·22	2N3055	0·55	2N4061	0·13
OC22	0·42	2G371B	0·13	2N2220	0·24	2N3391	0·15½	2N4062	0·13
OC23	0·46	2G373	0·18½	2N2221	0·22	2N3391A	0·17½	2N4284	0·18½
OC24	0·61½	2G374	0·18½	2N2222	0·22	2N3392	0·15½	2N4285	0·18½
OC25	0·42	2G377	0·33	2N2368	0·18½	2N3393	0·15½	2N4286	0·18½
OC26	0·27½	2G378	0·17½	2N2369	0·15½	2N3394	0·15½	2N4287	0·18½
OC28	0·55	2G381	0·17½	2N2369A	0·15½	2N3395	0·18½	2N4288	0·18½
OC29	0·55	2G382	0·17½	2N2411	0·26½	2N3402	0·23	2N4289	0·18½
OC35	0·46	2G401	0·33	2N2412	0·26½	2N3403	0·23	2N4290	0·18½
OC36	0·55	2G414	0·33	2N2646	0·51½	2N3404	0·31	2N4291	0·18½
OC41	0·22	2G417	0·27½	2N2711	0·23	2N3405	0·46	2N4292	0·18½
OC42	0·26½	2N388	0·38½	2N2712	0·23	2N3414	0·16½	2N4293	0·18½
OC44	0·16½	2N388A	0·60½	2N2714	0·23	2N3415	0·16½	2N5172	0·13
OC45	0·14	2N404	0·22	2M2904	0·18½	2N3416	0·31	2N5457	0·35
OC70	0·11	2N404A	0·31	2N2904A	0·23	2N3417	0·31	2N5458	0·35
OC71	0·11	2N524	0·46	2N2905	0·23	2N3525	0·82½	2N5459	0·44
OC72	0·15½	2N527	0·54	2N2905A	0·23	2N3646	0·10	2S301	0·55
OC74	0·15½	2N598	0·46	2N2906	0·16½	2N3702	0·11	2S302A	0·46
OC75	0·16½	2N599	0·49½	2N2906A	0·20	2N3703	0·11	2S302	0·46
OC76	0·16½	2N696	0·14	2N2907	0·22	2N3704	0·12	2S303	0·60½
OC77	0·27½	2N697	0·14½	2N2907A	0·24	2N3705	0·11	2S304	0·77
OC81	0·16½	2N698	0·26½	2N2923	0·15½	2N3706	0·10	2S305	0·92½
OC81D	0·16½	2N699	0·38½	2N2924	0·15½	2N3707	0·12	2S306	0·92½
OC82	0·16½	2N706	0·09	2N2925	0·15½	2N3708	0·07½	2S307	0·92½
OC82D	0·16½	2N706A	0·10	2N2926(G)		2N3709	0·10	2S321	0·61½
OC83	0·22	2N708	0·13		0·14	2N3710	0·10	2S322	0·46
OC84	0·22	2N711	0·33	2N2926(Y)		2N3711	0·10	2S322A	0·46
OC139	0·22	2N717	0·38½		0·12	2N3819	0·31	2S323	0·61½
OC140	0·22	2N718	0·26½	2N2926(O)		2N3820	0·55	2S324	0·77
OC169	0·27½	2N718A	0·55		0·11	2N3821	0·38½	2S325	0·77
OC170	0·27½	2N726	0·31	2N2926(R)		2N3823	0·31	2S326	0·77
OC171	0·27½	2N727	0·31		0·11	2N3903	0·31	2S327	0·77
OC200	0·27½	2N743	0·22	2N2926(B)		2N3904	0·33	2S701	0·46
OC201	0·31	2N744	0·22		0·11	2N3905	0·31	40361	0·44
OC202	0·31	2N914	0·15½	2N3010	0·77	2N3906	0·30	40362	0·49½
OC203	0·27½	2N918	0·33	2N3011	0·15½	2N4058	0·13		
OC204	0·27½	2N929	0·23						
OC205	0·38½	2N930	0·23						
OC309	0·44	2N1131	0·22						
OCP71	0·47½	2N1132	0·24						
ORP12	0·47½	2N1302	0·15½						
ORP60	0·44	2N1303	0·15½						
ORP61	0·44	2N1304	0·18½						
P346A	0·22	2N1305	0·18½						
P397	0·46	2N1306	0·23						
ST140	0·46	2N1307	0·23						
ST140	0·14	2N1308	0·25½						
ST141	0·18½	2N1309	0·25½						
TIS43	0·33	2N1613	0·22						
UT46	0·30	2N1711	0·22						
2G301	0·21	2N1889	0·35						
2G302	0·21	2N1890	0·49½						
2G303	0·21	2N1893	0·40½						
2G304	0·26½	2N2147	0·79						
2G306	0·44	2N2148	0·62½						
2G308	0·38½	2N2160	0·66						
2G309	0·38½	2N2192	0·38½						
2G339	0·22	2N2193	0·38½						
2G339A	0·17½	2N2194	0·38½						

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AA119	0·09	BY133	0·23	OA10	0·38½
AA120	0·09	BY164	0·55	OA47	0·07½
AA129	0·09	BYX38/30		OA70	0·07½
AAY30	0·10		0·46	OA79	0·07½
AAZ13	0·11	BYZ10	0·38½	OA81	0·07½
BA100	0·11	BYZ11	0·33	OA85	0·10
BA116	0·23	BYZ12	0·33	OA90	0·06½
BA126	0·24	BYZ13	0·27½	OA91	0·06½
BA148	0·15½	BYZ16	0·44	OA95	0·07½
BA154	0·13	BYZ17	0·38½	OA200	0·06½
BA155	0·15½	BYZ18	0·38½	OA202	0·07½
BA156	0·14½	BYZ19	0·31	SD10	0·05½
BY100	0·16½	CG62		SD19	0·05½
BY101	0·13	(OA91 Eq.)		1N34	0·7½
BY105	0·18½		0o05½	1N34A	0·07½
BY114	0·13	CG651		1N914	0·06½
BY126	0·15½	(OA70-OA79		1N916	0·06½
BY127	0·16½	Eq.)	0·06½	1N414B	0·06½
BY128	0·16½	OA5	0·38½	1S021	0·11
BY130	0·17½	OA5SL	0·23	1S951	0·06½

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U13	30 PNP-NPN Sil. Transistors OC200 & 2S 104	0·55
U14	150 Mixed Silicon and Germanium Diodes	0·55
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U19	25 Silicon NPN Transistors like BC108	0·55
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100	0·28	0·37	0·52	0·52	0·55	0·64	0·70	1·54
200	0·39	0·41	0·54	0·54	0·63	0·67	0·83	1·76
400	0·48	0·52	0·62	0·62	0·74	0·83	1·03	1·93
600	0·59	0·63	0·75	0·75	0·85	1·07	1·38	—
800	0·70	0·77	0·88	0·88	0·99	1·32	1·65	4·40

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100	0·04	0·07	0·06	0·15	0·18	0·26	0·83
200	0·06	0·10	0·07	0·16	0·22	0·27	1·10
400	0·07	0·15	0·08	0·22	0·30	0·41	1·38
600	0·08	0·18	0·11	0·26	0·38	0·50	2·05
800	0·11	0·19	0·12	0·28	0·41	0·61	2·20
1000	0·12	0·28	0·16	0·33	0·51	0·70	2·75
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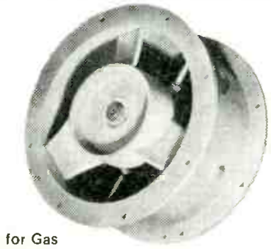

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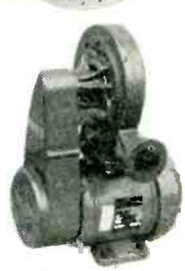

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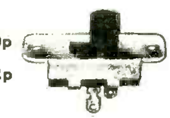

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H8/3	3µf	50v	4p	H7/7	100µf	25v	4p
H8/3A	4µf	50v	4p	H7/8	125µf	16v	5p
H8/4	4·7µf	25v	4p	H7/8A	100µf	35v	6p
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H8/5	5µf	10v	4p	H7/9A	125µf	4v	4p
H8/5A	5µf	150v	4p	H7/10	125µf	25v	6p
H8/6A	10µf	10v	4p	H7/10A	160µf	2·5v	3p
H8/7	10µf	70v	4p	H7/11	160µf	25v	6p
H8/8	16µf	35v	4p	H7/11A	150µf	16v	5p
H8/8A	16µf	16v	4p	H7/13A	200µf	25v	8p
H8/9	20µf	6v	2p	H7/14	220µf	50v	10p
H8/9A	20µf	70v	4p	H7/14A	220µf	16v	6p
H8/10	22µf	50v	4p	H7/15	220µf	25v	5p
H8/10A	22µf	100v	4p	H7/15A	220µf	35v	10p
H8/11	25µf	12v	4p	H6/1A	250µf	4v	3p
H8/11A	24µf	275v	4p	H6/2	250µf	25v	3p
H8/12	32µf	15v	4p	H6/3A	320µf	2·5v	3p
H8/12A	30µf	10v	4p	H6/4	320µf	10v	4p
H8/13A	32µf	50v	4p	H6/4A	330µf	16v	5p
H8/14	40µf	25v	5p	H6/5	330µf	25v	10p
H8/14A	40µf	16v	4p	H6/5A	330µf	35v	15p
H8/15	47µf	50v	4p	H6/7	400µf	15v	5p
H8/15A	40µf	35v	4p	H6/8	470µf	25v	10p
H7/1	50µf	6v	3p	H6/8A	470µf	35v	20p
H7/1A	50µf	10v	4p	H6/9	500µf	15v	4p
H7/2	50µf	50v	4p	H6/9A	400µf	40v	20p
H7/2A	64µf	2·5v	2p	H6/10	750µf	12v	5p
H7/3A	64µf	25v	4p	H6/13A	1000µf	25v	16p
H7/4	64µf	15v	4p	H5/2A	2200µf	16v	15p

MULLARD ELECTROLYTIC CAPACITATORS

071 and 072 Series

Type No.	Working Voltage Vdc.	Capacitance µF	Max. Ripple Current at 50°C	Weight	Price
071 15332	16	3300	2·4 amps	1oz	15p
071 15472	16	4700	3·9 amps	1oz	17p
071 15682	16	6800	5·8 amps	1½oz	22p
071 15103	16	10000	7·9 amps	2½oz	27p
071 18222	63	2200	5·8 amps	3oz	30p
072 15752	16	7500 + 7500	10·5 amps	3oz	37p
072 15113	16	11000 + 11000	13·8 amps	4½oz	49p
071 16222	25	2200	2·2 amps	1oz	15p
071 16472	25	4700	5·4 amps	1½oz	22p
072 16502	25	5000 + 5000	9·6 amps	3½oz	37p
072 16752	25	7500 + 7500	12·6 amps	4½oz	49p
072 17342	40	3400 + 3400	9·1 amps	3½oz	37p
072 17502	40	5000 + 5000	12·0 amps	4½oz	49p
071 18681	63	680	2·1 amps	1oz	15p
072 18172	63	1650 + 1650	7·8 amps	3oz	37p

106 and 107 Series

106 15103	16	10000	7 amps	2½oz	65p
106 16223	25	22000	17 amps	10oz	£1·12
106 17103	40	10000	12 amps	7½oz	94p
106 18153	63	15000	28 amps	18oz	£1·79
107 10222	100	2200	10 amps	5½oz	74p

Type No.	Voltage	Capacitance	Weight	Price
102 15163	16	16000	8oz	20p
104 90003	20	39000	16oz	30p
102 16802	25	8000	7oz	25p
104 17562	40	5600	5oz	25p
104 90001	45	20000	16oz	50p
104 18332	63	3300	5oz	25p

A further 10% discount on lots of 100 of any one type.

Please calculate the weight of your order and include appropriate postage.

Not over	Ordinary Parcels	Not over	Ordinary Parcels	Not over	Ordinary Parcels	Not over	Ordinary Parcels
1½lb	16p	4lb	25p	10lb	37p	18lb	57p
2lb	21p	6lb	29p	14lb	47p	22lb	67p

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BD 112 .. 25p
OC 36 .. 50p
BD 145 .. 25p

Small Signal N.P.N.
BC 108 .. 10p
BC 109 .. 10p
BF 194 .. 10p

Transmitting Types
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BLY 89A .. £5
BLY 93A .. £9

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BXY 27/28/32/35/36/37/38/39/40/41 .. £1

Microwave Detector
CAY 10 .. £5

Microwave Mixer
CL 7331 .. £20

Microwave Gunn Effect Oscillator
CL 8370 .. £10
CL 8380 .. £10
CL 8390 .. £10
CL 8470 .. £40

Microwave Tunnel Diodes
AEY 13 .. £5
AEY 16 .. £10

R.F. Transistors
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BF 194 .. 10p
AF 124 .. 20p

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TBA 510 Chrominance I.C. .. £1
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7440 .. 12p
7453 .. 12p
7470 .. 24p
7472 .. 24p
7473 .. 32p
7474 .. 32p
7482 .. 88p
7483 .. 95p
7490 .. 58p
7491 .. 78p
7492 .. 58p
7493 .. 58p
7495 .. 68p
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An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.

Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

Light sensitive aerosol spray .. **£1·00** plus
Developer and Etchant .. **50p** postage

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¼ and ½ watt. Most values in stock. 75p per 100. **10p** per dozen of any one value. WIRE WOUND MAINS DROPPERS. Hundreds of values from 0·7 ohm upwards. 1 watt to 50 watts. A large percentage of these are multi-tapped droppers for radio/television. Owing to the huge variety these can only be offered "assorted" at **50p** per dozen.

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17in × 2½in × 0·15in .. **55p**
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Spot Face Cutter **38p**. Pin Insert Tool **48p**.
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MULLARD POLYESTER CAPACITORS

500,000 in STOCK!!!

·001µf	·0018µf	·0056µf	·015µf	
·0012µf	·0022µf	·01µf	·033µf	
·0015µf	·0027µf	·012µf	·082µf	

20p dozen; 75p-100; £5-1,000; £40-10,000

·15µf	·18µf	·22µf	·39µf	·68µf

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ERIE MONOLITHIC CERAMIC CAPACITORS

3p each; 20p dozen; £1·75 per 100

10pf	68pf	560pf
15pf	100pf	620pf
22pf	150pf	680pf
33pf	220pf	1,000pf
39pf	330pf	
47pf	470pf	

RECTIFIERS 1N4007 1200 peak volts, 30 amps peak current, 1 amp mean current. 100 for £7·50, 1,000 £50.

£1 100 ¼-½ WATT RESISTORS, 100 CERAMIC CAPACITORS, 100 DIODES — PACK No. 1

£1 1 VERO-BOARD CUTTER, 5 2½ in. x 1 in. x ·15 BOARDS, 50 SQ. INS. "ODD PIECES" VERO — PACK No. 3

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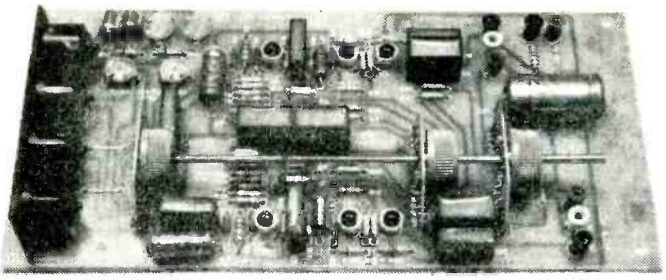

This is our Bailey/Burrows Stereo pre-amp front end. We think it is the best engineered kit of the best pre-amp circuit available, and there is a back end/tone control unit of similar advanced design to go with it which is only 1½" deep so it fits almost anywhere, but of course it's at its best in a Hart universal amplifier metalwork with a couple of Hart Bailey 30 watt power amps to keep it company. That's a recipe for real Hi-Fi with electronics you'll be too proud to cover up.

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TF1345/2 COUNTER FREQUENCY METER with plug-in units up to 220 Mc/s. P.O.A.

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8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc. Full spec. and price on request.

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Also as above 20 V. M.C. size 60 × 60 mm. type S.2193.254. **£1·95** post paid.

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Plug-in Units: CA, G, 1A1, 10A1. P.O.A.

QUANTIZATION DISTORTION TESTER. Checks a.f. to a.f. distortion of p.c.m. systems. Utilises system power supply. Output level: Variable in 1 dB steps, from —50 to +2 dBm. Accuracy: ±0·2 dB at +2 dBm, ±0·5 dB incremental. Quantization distortion: 0 to —40 dB in 0·5 dB steps. Meter indication: True r.m.s. Input impedance: 600Ω ±10% balanced.

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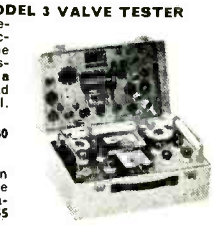
Enables comprehensive characteristics to be plotted, or measures valves on a simple good/bad basis. £55 incl. carr.



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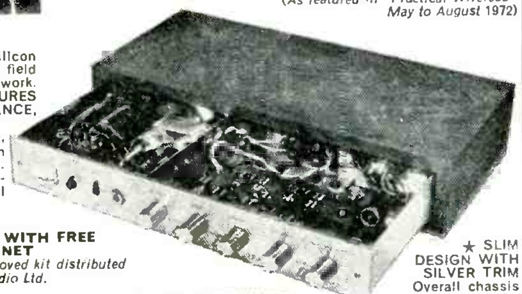

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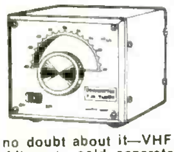

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TOTAL PRICE **£6.97**

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SC40A	100	85p
SC40B	200	90p
SC40D	400	£1·00
SC40E	500	£1·20
10 AMP RANGE (TO48)		
SC45A	100	95p
SC45B	200	£1·00
SC45D	400	£1·25
SC45E	500	£1·45
15 AMP RANGE (TO48)		
SC50A	100	£1·25
SC50B	200	£1·35
SC50D	400	£1·65
SC50E	500	£1·85
DIAC D32		25p
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40430	(TO66)	85p
40669	(Plastic)	£1·00
40486	(TO5)	80p

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Type	Volts P.I.V.	Price 1-11
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BO5/05	50	20p
BO5/10	100	25p
ONE AMP TUBULAR ½×¾H		
B1/05	50	25p
B1/10	100	25p
B1/20	200	30p
B1/60	600	35p
ONE AMP (G.I.) TUBULAR		
W005	50	30p
W01	100	35p
W02	200	40p
W06	600	45p
TWO AMPS ½H×½L×½		
B2/05	50	35p
B2/100	100	40p
B2/200	200	45p
B2/600	600	50p
B2/1000	1000	60p
FOUR AMPS ½H×½L×½		
B4/100	100	60p
B4/200	200	65p
B4/400	400	70p
B4/600	600	75p
B4/800	800	£1·00
SIX AMPS ½H×½L×½		
B6/100	100	70p
B6/200	200	75p
B6/400	400	90p
B6/600	600	£1·00

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CRS 1/10	100	30p
CRS 1/20	200	30p
CRS 1/40	400	35p
CRS 1/60	600	45p
THREE AMP (TO48)		
CRS 3/05	50	30p
CRS 3/10	100	30p
CRS 3/20	200	35p
CRS 3/40	400	45p
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IN4004	400	8p
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'C' Core. Pri. 220-240v. Sec. 24v. 3a. Table top connections. **£2·00.** P.P. 40p. Pri. 220-240v. Sec. 11v. 9a. 'C' Core. Table top connections. **£2·50.** P.P. 40p. Drake. Pri. 220-240v. Sec. 14v. 6a.

H.T. SMOOTHING CHOKES
PARMEKO. Potted Type. 10h. 180 m/a. **£1·50** P.P. 25p. 15h. 300 m/a. **£2·50** P.P. 50p. 10h. 120 m/a. **60p.** P.P. 20p. 15h. 75 m/a., 10h. 75 m/a., 50h. 25 m/a., **50p.** P.P. 20p. Swinging Type. 34h. 60 m/a./70h. 35 m/a. 2·8KV. D.C. wkg. **85p.** P.P. 35p.

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COILS AND I.F. TRANSFORMERS IN LARGE-SCALE PRODUCTION FOR RECEIVER MANUFACTURERS

P.11 SERIES 10 mm. × 10 mm. × 14 mm. Ferrite cores 3 mm. 472 kc/s operation. Single-tuned I.F.s and Oscillator Coils.

P.55 SERIES 12 mm. × 12 mm. × 20 mm. Ferrite cores 4 mm. 472 kc/s operation. Single-tuned I.F.s and Oscillator Coils.

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These ranges are available to manufacturers in versions suitable for most of the popular types of Transistors. The Oscillator coils can be modified to enable specific tuning capacitors to be used provided that bulk quantities are required.

OUR WINDING CAPACITY NOW EXCEEDS 50,000 ITEMS PER WEEK

On the most up-to-date and efficient machines backed by a skilled assembly labour force for all types of coils and assemblies.

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R.S.C. G66 MkII 6+6 WATT STEREO AMPLIFIER

High Quality Output. Rating I.H.F.M. Ind. Ganged Controls Bass, Treble, Vol. and Balance. Solid state constr. employing 10 Trans. plus diodes. Range 20-20,000Hz. Bass control ± 12 dB Treble ± 13 dB. Selector switch P.U. or Tape/Radio. Output for 3-15 ohm speakers. Standard 200-250v. 50 Hz mains operation. Attractive Black/Silver metal face plate and matching knobs.

COMPLETE KIT OF PARTS INC. FULLY WIRED PRINTED CIRCUIT £12·65 **OR FACTORY BUILT IN TEAK VENEERED CABINET £16·50**

R.S.C. SUPER 30 MkIII HIGH FIDELITY STEREO AMPLIFIER

BUILD AN AMPLIFIER WORTH APPROXIMATELY DOUBLE THE KIT PRICE INCLUDING CABINET
Only high grade components by leading manufacturers

- Push Button Selector Switching
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- Neon Indicator
- Satin Silver Finish Metal Fascia
- Solid State Circuitry
- Twenty Silicon Transistors
- Four Diodes, Four Rectifiers

For Magnetic or Ceramic Pick-Ups regardless of Price
Output (per channel) 15 watts RMS into 8Ω
Frequency Response 7 Hz to 70 KHz ± 1½ dB

COMPLETE KIT (less cabinet). Carr. 70p. Cabinet if req. £5 extra **£27·50**

Send S.A.E. for full descriptive leaflet

FACTORY BUILT UNIT INC. CABINET with 12 months' guarantee. Or Dep. £7 and 9 monthly payments £4·54 (Total £47·86) **£42·50**

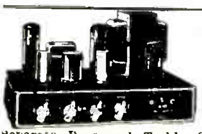
R.S.C. STEREO FM TUNER NOW AVAILABLE. Visually matches Super 30 Mk. III at **£37·50**

FANE ULTRA HIGH POWER LOUDSPEAKERS

Power Rating R.M.S. continuous. 2 years guarantee. Carr. free

12" 'POP' 50	15" 'POP' 60	18" 'POP' 100
50 Watts, 15Ω, 13,000 Gauss	60 Watts, 8/15Ω, 14,000 Gauss	100 Watts, 8/15Ω, 14,000 Gauss
£11·99	**£14·19**	**£25·15**
Or Dep. £2 and 9 monthly payments £1·33 (Total £13·97)	Or Dep. £3·30 and 9 monthly payments £1·43 (Total £16·17)	Or Dep. £6·00 and 9 monthly payments £2·45 (Total £28·05)

Pair suitable for all purposes. SUITABLE FOR BASS GUITAR, ELECTRONIC ORGAN, etc.



R.S.C. A10 30 WATT HI-FI AMPLIFIER

Including 2 ind. controlled inputs
Separate Bass and Treble Controls. Valves EF86, EF86, ECC83, GZ34, EL34, EL34. Sensitivity 36mV. For High Imp. mic. or pick-ups. Designed to high fidelity standards for CLUBS, SCHOOLS, THEATRES, DANCE HALLS, DISCOTHEQUES, etc. For use with Electronic Organ, Bass or Lead Guitar. For Gram, Radio or Tape. For 3 or 15 ohm speakers.
Twin-handled metal cover £2·10
FACTORY BUILT with 12 months' guarantee. Or Dep. £4 and 9 monthly payments £2·27 (Total £24·43) S.A.E. for leaflet **£21·75**

FANE SPEAKERS 'POP' 25/2

12" 25 WATT Dual Cone 15 ohms NOT for Bass Guitar. **£7·43** Or Dep. £1·25 and 9 monthly payments 83p (Total £8·72)

HI-FI SPEAKER ENCLOSURES

Teak veneer finish. Pleasing design. Acoustically lined. All sizes approx.
JE8 16 × 11 × 9 in. Pressurised. Excellent results with 8 in. Hi-Fi Speaker. **£5·50**
SE8 for optimum results with any 8 in. Hi-Fi Speaker. 19 × 10½ × 9 in. **£6·50**
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FULLY GUARANTEED. Interleaved and Impreg where necessary. Primaries 200-250v. 50 Hz. Screened

MIDGET CLAMPED TYPE 2½ × 2½ × 2½in.

250v., 60mA, 6.3v. 2a.	£1·10
250-0-250v., 60mA, 6.3v. 2a.	£1·16

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a.	£1·55
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 130mA, 6.3v. 4a., c.t., 6.3v 1a. For Mullard 510 Amplifier	£2·95
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a.	£2·95
425-0-425v. 200mA, 6.3v. 4a. c.t., 5v. 3a.	£5·45
425-0-425v. 200mA, 6.3v. 4a., 6.3v. 3a, 5v. 3a	£5·60
450-0-450v. 250mA. 6.3v. 4a., c.t., 5v. 3a.	£6·00

TOP SHROUDED DROP-THROUGH TYPE

250-0-250v 70mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·49
250-0-250v. 100mA, 6.3v. 3.5a.	£1·71
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a.	£1·75
350-0-350v. 80mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·81
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 130mA, 6.3v. 4a. c.t. 6·3v. 1a. Suitable for Mullard 510 Amplifier	£2·85
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
350-0-350v. 150mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·85

FILAMENT or TRANSISTOR POWER PACK Types 6.3v. 1.5a. 55p; 6.3v. 2a. 60p; 6.3v. 3a. 85p; 6.3v. 6a. £1·45; 12v. 1a. 61p; 0-9-18v. 1½a. £1·25; 0-12-25-42v. 2a. £1·95; 12v. 3a. or 24v. 1.5a. £1·50;

CHARGER TRANSFORMERS 0-9-15v. 1½a. £1·10; 2½a., £1·25; 3a., £1·40; 5a., £1·60; 6a., £1·85; 8a., £2·20.

AUTO (Step UP/Step DOWN) Transformers 0-110/120v., 200-230-250v. 50-80 watts £1·25; 150w., £2·10; 250w., £3·00; 500w., £6·40

OUTPUT TRANSFORMERS

Standard Pentode 5,000Ω to 7,000Ω to 3Ω	55p
Push-Pull 8 watts EL84 to 3Ω or 15Ω	95p
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Push-Pull EL84 to 3 or 15Ω 10-12 watts	£1·50
Push-Pull Ultra Linear for Mullard 510, etc	£2·45
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15Ω	£2·20
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15Ω	£3·65

BATTERY/MAINS CONVERSION UNITS

R.S.C. BM1 battery eliminator completely replaces 1·5v. and 90v. Radio batteries where norma 200-250v. AC mains is available. Ready for use **£4·15**

FANE 807T HIGH FIDELITY SPEAKER 8" 10 WATT

A full range unit to provide excellent sound quality in suitable enclosure. Roll P.V.C. cone surround and long throw voice coil to achieve very low fundamental resonance of 30 Hz. Tweeter cone extends high note response. Frequency range 25-15,000 Hz. Imp. 3 or 8/15Ω. (state requirement.)
REMARKABLE VALUE £3·70

MODEL 803T 8" 15w. with parasitic Tweeter. Response 25 Hz to 15 KHz. Gauss 13,000 Imp 3 or 8-15 ohms. ONLY **£4·95**

FANE MODE ONE HI-FI SPEAKER KIT

inc. 803 8" unit, 303 Pressure Tweeter, Printed circuit, inductive capacitive cross-over, acoustic filling panels, screws, etc. Post free Response 30-20,000 Hz ONLY **£9·39**

HIGH FIDELITY SPEAKERS

AUDIOTRINE RANGE

Heavy construction. Highly efficient ceramic magnets. Plastiflex cone surrounds. "D" indicates Tweeter cone providing frequency range up to 15 KHz. Exceptional performance at low cost.

HF 808T	8"	10W	£2·88
HF 102D	10"	10W	£3·30
HF 120	12"	15W	£4·85
HF 120D	12"	15W	£5·50
HF 126	12"	15W	£6·35
HF 126D	12"	15W	£6·85

Please state impedance required. 3 or 8-15 ohm.

HI-FI SPEAKER SYSTEMS

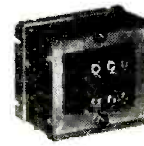
Audiotrine 121K. 12 in. 15 watt. 11,000 Gauss bass unit. Cross-over unit and Tweeter. Smooth response and wide frequency range ensure realistic sound reproduction. Carr. 33p **£6·50**

Audiotrine 125K with extra sensitive 15,000 Gauss 12 in. speaker. **£7·65**

TRANSFORMERS

MAINS ISOLATING SERIES

Primary 200-250 Volts Secondary 240 Volts Centre Tapped (120V) and Earth Shielded
ALSO AVAILABLE WITH 115/120V SECONDARY WINDING



Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	£	P & P p
07	20	1	11	7·0 × 6·0 × 6·5	1·77	30
100	60	3	8	8·9 × 8·0 × 7·7	2·62	36
61	100	5	12	10·2 × 8·9 × 8·3	2·88	52
30	200	9	8	12·0 × 10·3 × 10·0	4·83	52
62	250	12	4	9·5 × 12·7 × 11·4	6·38	67
55	350	15	0	14·0 × 10·8 × 12·4	8·55	82
63	500	27	0	17·1 × 11·4 × 15·9	12·32	*
92	1000	40	0	17·8 × 17·1 × 21·6	22·70	*
128	2000	63	0	24·1 × 21·6 × 15·2	37·50	*
129	3000	84	0	21·6 × 21·6 × 20·3	58·67	*
190	6000	178	0	31·1 × 35·6 × 17·1	96·27	*

440V 300VA ISOLATOR, Primary 440V Secondary 240V, Centre Tapped Screened and Shrouded, £10·37. P & P 67p.

AUTO SERIES (NOT ISOLATED)

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	£	P & P p
113	20		11	7·3 × 4·3 × 4·4	0-115-210-240	0·93	22
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	1·82	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	2·20	36
66	300	6	0	10·2 × 10·2 × 9·5	,, ,,	4·28	52
67	500	12	8	14·0 × 10·2 × 11·4	,, ,,	6·35	67
84	1000	16	0	11·4 × 14·0 × 14·0	,, ,,	11·54	82
93	1500	28	9	13·5 × 14·9 × 16·5	,, ,,	16·72	*
95	2000	40	0	17·8 × 16·5 × 21·6	,, ,,	21·82	*
73	3000	45	8	17·4 × 18·1 × 21·3	,, ,,	29·70	*

TOTALLY ENCLOSED 115V AUTO TRANSFORMERS

115V 500 Watt totally enclosed auto transformer, complete with mains lead and two 115V outlet sockets, £8·63. P & P 67p
Also available a 20 Watt version. £1·84. P & P 22p.

LOW VOLTAGE SERIES (ISOLATED)
PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps. 12V	24V	Weight lb	oz	Size cm.	Secondary Windings	£	P & P p
111	0·5	0·25		12	7·6 × 5·7 × 4·4	0-12V at 0·25A × 2	0·93	22
213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	1·11	22
71	2	1	1	0	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·46	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	2·04	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	2·46	42
108	8	4	5	4	10·0 × 8·3 × 8·2	0-12V at 4A × 2	2·73	52
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	3·23	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	4·99	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	6·35	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	11·73	82
226	60	30	34	0	17·0 × 14·5 × 12·5	0-12V at 30A × 2	21·57	*

30 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz.	Size cm.	Secondary Taps	£	P & P p
112	0·5	1	4	8·3 × 3·7 × 4·9	0-12-15-20-24-30V	1·11	22
79	1·0	2	0	7·0 × 6·4 × 6·0	,, ,,	1·48	36
3	2·0	3	2	8·9 × 7·0 × 7·6	,, ,,	2·21	36
20	3·0	4	6	10·2 × 8·9 × 8·6	,, ,,	2·72	42
21	4·0	6	0	10·2 × 10·0 × 8·6	,, ,,	3·23	52
51	5·0	6	8	12·1 × 10·0 × 8·6	,, ,,	4·02	52
117	6·0	7	8	12·1 × 10·0 × 10·2	,, ,,	4·80	52
88	8·0	10	0	14·0 × 11·7 × 10·0	,, ,,	6·20	67
89	10·0	12	2	14·0 × 10·2 × 11·4	,, ,,	7·85	67

50 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
102	0·5	1	11	7·0 × 7·0 × 5·7	0-19-25-33-40-50V	1·46	30
103	1·0	2	10	8·3 × 7·3 × 7·0	,, ,,	2·13	36
104	2·0	5	0	10·2 × 8·9 × 8·6	,, ,,	2·96	42
105	3·0	6	0	10·2 × 10·2 × 8·3	,, ,,	4·01	52
106	4·0	9	4	12·1 × 11·4 × 10·2	,, ,,	5·31	52
107	6·0	12	4	12·1 × 11·1 × 13·3	,, ,,	7·55	67
118	8·0	18	9	13·3 × 13·3 × 12·1	,, ,,	10·25	97
119	10·0	19	12	16·5 × 11·4 × 15·9	,, ,,	12·85	97

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
124	0·5	2	4	8·3 × 9·5 × 6·7	0-24-30-40-48-60V	1·48	36
126	1·0	3	0	8·9 × 7·6 × 7·6	,, ,,	2·06	36
127	2·0	5	6	10·2 × 8·9 × 8·6	,, ,,	3·23	42
125	3·0	8	8	11·9 × 9·5 × 10·0	,, ,,	4·92	52
123	4·0	10	6	11·4 × 9·5 × 11·4	,, ,,	6·35	67
120	6·0	16	12	13·3 × 12·1 × 12·1	,, ,,	9·20	82
122	10·0	23	2	16·5 × 12·7 × 16·5	,, ,,	15·23	*

EQUIPMENT TRANSFORMER

REF 238 PRI 0240 SCREEN SEC 3·0 3V RMS at 200mA SIZE CM 2·8 × 2·6 × 2·0 WEIGHT 2oz £1·08 P & P 10p.

LEAD ACID BATTERY CHARGER TYPES
PRIMARY 200-250 VOLT FOR CHARGING 6 OR 12 VOLT BATTERIES

Ref. No.	Amps.	Weight lb	oz	Size cm.		£	P & P p
45	1·5	1	9	7·0 × 6·0 × 6·0	Please note, these units do not include rectifier.	1·47	30
5	4·0	3	11	10·2 × 7·0 × 8·3		2·23	42
86	6·0	5	12	10·2 × 8·9 × 8·3		3·37	52
146	8·0	6	4	8·9 × 10·2 × 10·2		3·84	52
50	12·5	11	14	13·3 × 10·8 × 12·1		5·72	67

All ratings are continuous. Standard construction: open with solder tags and wax impregnation. Enclosed styles to order.

TRANSISTORS

BC107/108/109 9·0p each	2N 3055 60p each with mica and bushes	AD 161/162 60p pair with mica and bushes
25+ 7·5p	25+ 55p	25+ 55p
100+ 6·5p	100+ 45p	100+ 50p
500+ 6·0p	500+ 40p	500+ 45p
Minimum order 10 pieces this range.		1000+ 40p

★ Quantity prices on application

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AS SUPPLIED TO THE POST OFFICE
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Standard Post Office type
Guaranteed in working order

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P & P 15p EACH

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B79	4	IN4007 Sil. Rec. diodes, 1,000 PIV lamp plastic	50p
B81	10	Reed Switches Reed Relay Inserts 1¼" long	50p
B99	200	Mixed Capacitors. Approx. quantity, counted by weight	50p
H4	250	Mixed Resistors. Approx. quantity, counted by weight	50p
H7	40	Wirewound Resistors. Mixed types and values	50p
H40	20	BFY50/2, 2N696, 2N1613 NPN Silicon uncoded TO-5	50p
H9	2	OCP71 Light Sensitive Photo Transistor	50p
H39	10	Integrated circuits. 6 Gates BMC 962, 4 Flip Flops BMC 945	50p
H30	20	1 Watt Zener Diodes. Mixed Voltages 6.8–43V.	50p
H35	100	Mixed Diodes. Germ. Gold bonded etc. Marked and Unmarked	50p
H28	20	OC200/1/2/3 PNP Silicon uncoded TO 5 can	50p
H38	30	Short lead Transistors. NPN Silicon Planar types	50p
H41	2	Power Transistors Comp. Pair BD131/132	50p

UNMARKED UNTESTED PAKS

B66	150	Germanium Diodes Min. glass type	50p
B83	200	Trans. manufacturers' rejects all types NPN, PNP, Sil. and Germ.	50p
B84	100	Silicon Diodes DO-7 glass equiv. to OA200, OA202	50p
B86	100	Sil. Diodes sub. min. IN914 and IN916 types	50p
B88	50	Sil. Trans. NPN, PNP equiv. to OC200/1, 2N706A, BSY95A, etc.	50p
B1	50	Germanium Transistors PNP, AF, and RF	50p
H6	40	250mW Zener Diodes DO-7 Min. Glass Type	50p
H34	15	Power Transistors, PNP, Germ. NPN Silicon TO-3 Can. P & P 5p extra.	50p
H17	20	3 Amp. Silicon Stud Rectifiers. Mixed volts	50p
H15	30	Top Hat Silicon Rectifiers, 750mA Mixed volts	50p
H16	15	Experimenters Pak of Integrated Circuits. Data supplied	50p
H26	40	NPN Silicon Trans. 2N3707-11 range, low noise amp.	50p

MAKE A REV COUNTER FOR YOUR CAR

The 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a linear and accurate rev. counter for any car with normal coil ignition system.

£1 each

OVER 1,000,000 TRANSISTORS IN STOCK

We hold a very large range of fully marked, tested and guaranteed Transistors, Power Transistors, Diodes and Rectifiers at very competitive prices. Please send for Free Catalogue.

600,000 Silicon Planar Plastic Transistors, unmarked, untested — factory clearance Audio PNP, similar to ZTX500, 2N3702/3, BCY70 etc. Audio NPN, similar to ZTX300, 2N3708/9, BC107/8/9, BC168/9 etc. R.F. NPN and Switching NPN.

Please state type of Transistor required when ordering.

ALL AT 500 for £3.00, 1,000 for £5.00, 10,000 for £40.00.

OUR VERY POPULAR 3p TRANSISTORS

FULLY TESTED & GUARANTEED

TYPE "A" PNP Silicon alloy, TO-5 can.
TYPE "B" PNP Silicon, plastic encapsulation.
TYPE "E" PNP Germanium AF or RF.
TYPE "F" NPN Silicon plastic encapsulation.
TYPE "G" NPN Silicon, similar ZTX300 range.
TYPE "H" PNP Silicon, similar ZTX500 range.

Various Types

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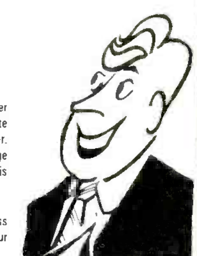

A CROSS HATCH GENERATOR FOR £3.50

YES, a complete kit of parts including Printed Circuit Board. A four position switch gives X-hatch, Dots, Vertical or Horizontal lines. Integrated Circuit design for easy construction and reliability. This is a project in the September edition of Practical Television.

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Full of Short Lead Semiconductors & Electronic Components, approx. 170. We guarantee at least 30 really high quality factory marked Transistors PNP & NPN, and a host of Diodes & Rectifiers mounted on Printed Circuit Panels. Identification Chart supplied to give some information on the Transistors.

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100,000 Plastic Power Transistors in stock, more on way!

NOW IN TWO RANGES

These are 40W and 90W Silicon Plastic Power Transistors of the very latest design, available in NRP or PNP at the most shatteringly low prices of all time. We have been selling these successfully in quantity to all parts of the world and we are proud to offer them under our Tested and Guaranteed terms.

	1-12	13-25	26-50
RANGE 1 VCE. Min. 15 HFE. Min. 15			
40 Watt	20p	18p	16p
90 Watt	24p	22p	20p
RANGE 2 VCE. Min. 40 HFE. Min. 40			
40 Watt	30p	28p	26p
90 Watt	35p	33p	30p

Complementary pairs matched for gain at 3 amps. 10p extra per pair. Please state NPN or PNP on order.

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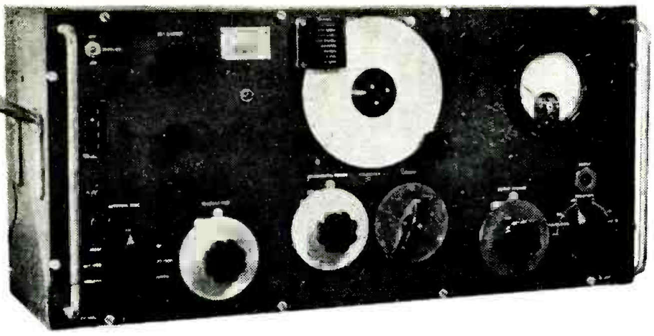

MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25 Mc/s in 8 ranges. Incremental: ±1% at 1 Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52·5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements 29 × 12¼ × 10 in. Secondhand condition. **£27·50** each, Carr. £1·50.

SIGNAL GENERATOR TYPE 902: (P.R.D.). A portable, general-purpose, broadband, microwave signal generator designed for testing and maintenance of aircraft radio and radar receivers in the SHF band. The RF output level is regulated by a variable attenuator calibrated in dbm. The frequency dial is calibrated in Mc/s. Provision is made for external modulation. Power Supply—115V, ±10% A.C., 50 c/s. Freq.—3650-7300 Mc/s. Internal Transmission—CW, Pulse, FM. External Transmission—Square Wave, Pulse. Power O/put—0.2 milliwatts. O/put Attenuator: −7 to −127 dbm. Load—50Ω. Price: **£135** each + £2 carr.

TEST SET TS-147C: Combined signal generator, frequency meter and power meter for 8500-9600 Mc/s. CW or FM signals of known freq. and power or measurement of same. *Signal Generator:* O/put −7 to −85 dbm. Transmission—FM, PM, CW. Sweep Rate—0-6 Mc/s per microsec. Deviation—0-40 Mc/s per sec. Phase Range—3-50 microsec. Pulse Repetition Rate—to 4000 pulses per sec. RF Trigger for Sawtooth Sweep—5-500 watts peak. 0.2-6 microsec. duration, 0.5 microsec pulse rise time. Video Trigger for Sawtooth Sweep—Positive polarity, 10-50V peak. 0.5-20 microsec duration at 10% max. amplitude, less than 0.5 microsec rise time between 90% and 10% max. amplitude points. *Frequency Meter:* Freq. 8470-9360 Mc/s. Accuracy—+2.5 Mc/s per sec. absolute, +1.0 Mc/s per sec. for freq. increments of less than 60 Mc/s relative, ±1.0 Mc/s per sec. a 9310 Mc/s per sec. calibration point. Accuracy measured at 25° C and 60 humidity. *Power Meter:* Input: +7 to +30 dbm. Output −7 to −85 dbm. Price: **£75** each + £1 carr.

SIGNAL GENERATOR TS-403B/U (or URM-61A): (Hewlett Packard). A portable, self-contained, general-purpose test equipment designed for use with radio and radar receivers and for other applications requiring small amounts of RF power such as measuring standing-wave ratios, antenna and transmission line characteristics, conversion gain, etc. Both the output freq. and power are indicated on direct-reading dials. 115V, AC, 50 c/s. Freq.—1800-4000 Mc/s. CW, FM, Modulated Pulse—40-4000 pulses per sec. Pulse Width—0.5-10 microsecs. Timing —Undelayed or delayed from 3-300 microsecs from external or internal pulse. O/put—1 milliwatt max., 0 to −127 db variable. O/put Impedance—50Ω. Price **£120** used, excellent condition. Unused as new condition **£150** + carr. £2.

TS-382/U AUDIO OSCILLATOR: 20 to 200,000 c/s. in four ranges. Freq. meter check 60 c/s. and 400 c/s. Emission CW. O/put voltage: 1 uv to 10V ±3% in seven ranges. Power req. 115V AC single phase. Price **£20** each, used good condition. Unused condition **£30** + carr. £1.50.

CT150 Portable valve-tester suitable for testing a wide range of valves. Manufactured by Avo. **£55** each + £2 carr.

FREQUENCY METER BC-221: 125-20,000 Kc/s, complete with original calibration charts. Checked out, working order. **£18·50** + £1·00 carr. BC-221 Unused as new condition complete with headset, spare valves, charts. **£35·00** + £2·00 carr.

TS-452 F.M. SWEEP GENERATOR: Power supply 115V, 50c/s, 5-100MHz in 6 bands (rf o/put); 5-102MHz in 4 bands (freq. meter). Emission: F.M. R.F. Voltage o/put ·25V. Input impedance 470 ohms. O/put impedance 73 ohms. Displays band pass characteristics on 3in. C.R.T. S/hand good condition **£95·00** + £2·00 carr.

TS-419/URM 64 SIGNAL GENERATOR: Freq. 900-2100MHz. CW or pulse emission. Power o/put Zero dbm-120dbm continuously adjustable to ·2uv into 50. O/put impedance 50 ohms with VSWR of 2:1. 115V a.c. 50 c/s. As new condition **£150·00** + £2·00 carr.

TS-622/URM 44 SIGNAL GENERATOR: Freq. range —7 to 11 GHz Power o/put —10 to 127 dbm; Emission CW, FM, Pulse. Direct reading dials for both frequency and power. Operates on 115 volts, 50-1000Hz. As new condition **£175·00** + £2·00 carr.

CT.52 MINIATURE OSCILLOSCOPE: Portable. Operates from 115V or 250V 50-60c/s; or 180V 500c/s. A small compact tropicalised instrument designed to meet requirements of radar and communication engineers and general electronic service. Measures 9 in. × 8 in. × 6½in. Time base 10c/s-40Kc/s. Y plate sensitivity 40V per cm. Tube 2¾in. Frequency compensated amplifier up to 38dB gain. Bandwidth up to 1 Mc/s. Single sweep facilities. Complete with test leads, metal transit case. As new **£27·50** each. Carr. **£1.**

TRANSFORMER HV: 228V input 19,500–0–19,500 4.5KVA, Wt. 220 lbs. **£30** each. Carr. **£4.**

MODULATOR UNIT: complete with transformer and 2×807 valves mounted in 19 in. chassis × 8 in. high × 8 in. deep. **£4·50** secondhand cond., or **£6·50** new cond. Carriage **£1.**

RF UNIT: suitable for use with the above unit. Complete with 2×3E29 valves. Ideal for conversion to 4 metres. **£5** secondhand cond., or **£7·50** new cond. Carriage **£1.**

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 × 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19"Wx11"Hx14"D. (All connections at the rear.) Excellent condition **£6·50** each, carr. £1.

AUTO TRANSFORMER: 230-115V, 50-60c/s, 1000 watts, mounted in a strong steel case 5" × 6½" × 7". Bitumen impregnated. **£7** each, Carr. 75p. 230-115V, 50-60c/s, 500 watts. 7" × 5" × 5". Mounted in steel ventilated case. **£4·00** each, Carr. 75p.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7·50** each, 75p carr.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3·50** each, post 50p.

APN-1 INDICATOR METER, 270° Movement. Ideal for making rev. counter. **£1·25**, post 30p.

AIRCRAFT SOLENOID UNIT S.P.S.T.: 24V, 200 Amps, **£2** each, 30p post.

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each, 0·9 ohms. Tolerance ± 1% **£3** each, 25p post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ± 1% **£3·50** each, post 30p.

CRYSTAL TEST SET TYPE 193: Used for checking crystals in freq. range 3000-10,000Kc/s. Mains 230V, 50c/s. Measures crystal current under oscillatory conditions and the equivalent parallel resistance. Crystal freq. can be tested in conjunction with a freq. meter. **£12·50** each, £1 carr.

VARIAC TRANSFORMERS: Input 115V, output 0-135V at 2 Amps. **£3** each 75p post. Input 115V, output 135V at 5 Amps. **£5** each, 75p post.

RACK CABINETS: (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high × 21 in. wide × 16 in. deep, with rear door. **£12** each, £2·50 Carr. OR 4 ft. high × 23 in. wide × 19 in. deep, with rear door. **£8·50** each, £2 Carr.

INSTRUMENT CABINETS: 19"W. × 16"H. × 16"D. **£5·00** + £1·25 carr. 19"W. × 10"D. × 5"H. **£2·50** + £1·00 carr.

FUEL INDICATOR Type 113R: 24V complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in 3in. diameter case. Price **£2** each, 30p post.

TS-418/URM49 SIGNAL GENERATOR: Covers 400-1000MHz range. CW Pulse or AM emission. Power Range 0-120 dbm. **£125** each. Carr. £1·50.

TN/130/APR.9 UHF TUNING UNIT: Freq. 4300-7350MHz. IF Output 160MHz with bandwidth of 20MHz and is electrically tuned by a d.c. reversible motor. **£27·50** each. Carr. £1.

APR-4 AM RADIO RECEIVER: 90-1000MHz. This receiver is suitable for monitoring and measuring frequencies as well as relative signal strength. Power Supply 115V 50c/s. **£100** each. Carr. £2.

R-361 RECEIVER: 225-400MHz. 1 preset channel crystal controlled. Superheterodyne, voice and CW. 230V 50c/s input. **£35** each. Carr. £1·50.

TS-130 TEST SET: Complete with RF Probe type 1019 Freq. 0·9-12·5KHz, and RF Probe type 1020 Freq. 0·3-1KHz. Also slotted line attenuator 1M-34/U. Freq. 0·3-4KHz; and connectors. **£45** each. £1 carr.

CLASS "D" WAVEMETER NO. 2: Crystal controlled heterodyne frequency meter covering 2-8MHz. Power supply 6V d.c. Good secondhand cond. **£7·50** each. Post 60p.

RCA TE-149 HETERODYNE WAVEMETER: V-cut, 1MHz crystal (0·005%). Accuracy better than 0·02%. Dial directly calibrated every 1KHz from 2·5-5MHz. Useful harmonics up to 20MHz. Provision for fitting internal dry batteries. "As new" complete with Manual and Spares. **£14** each. Carr. 75p.

POWER UNIT TYPE 24: (for R.216 Receiver) A.C. operated 100-125V or 200-250V, 50c/s. "As new" **£10** each. Carr. 75p.

FILTER VARIABLE BAND PASS NO. 1: Dual channel unit, each channel has variable slot frequency of 500-900Hz, 1200-1600Hz and band pass facility. 600Ω input/output, monitor input and high impedance output jacks. Standard rack mounting 3½in. deep panel. Mains operation 200-250V 50c/s. "As new" **£6·50** each. Carr. 75p.

ROTARY INVERTERS: TYPE PE.218E—input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1 Ph. P.F.9. **£17·50** each. Carr. £1·50.

POWER SUPPLY: 230V a.c. input; 3000V @ 2·5mA; 4v @ 1 Amp, 300-0-300 200mA; 6V @ 7 Amp; 6V @ 3 Amp. With smoothing capacitors etc. **£10·00** each. £1·50 carr.

GEARED MOTOR: 24V D.C., current 150mA, output 1 rpm, **£1·50** each, 30p post. **ASSEMBLY UNIT** with Letcherbar Tuning Mechanism and potentiometer, 3 rpm, **£2** each 30p post. **SYNCHROS:** and other special purpose motors available. List 3p.

ACTUATOR UNIT: With 115V d.c. geared motor; o/put 12·5 rpm; torque 16 ins. oz; reversible; microswitches and potentiometer. **£3·50** ea. + 40p post.

DALMOTORS: 24-28V d.c. at 45 Amps, 750 watts (approx. 1hp) 12,000rpm. **£5** each, 60p post.

MOTOR: 240V single phase, 2,400 rpm. 1/40 H.P. approx. Price **£1·75** each, 30p post.

CONDENSERS: 30 mfd 600 v wkg. d.c., **£3·50** each, post 50p. 15 mfd 330 v a.c., wkg., **75p** each, post 25p. 10 mfd 600 v. **43p** each, 25p post. 8 mfd 2500 v. **£5** each, carr. 63p. 8 mfd 600 v. **43p** each, post 15p. 8 mfd. 1% 300 v. D.C. **£1·25**, post 25p, 4 mfd 3000 v. wkg. **£3** each, post 37p. 4 mfd 2000 v. **£2** each, post 25p. 4 mfd 600 v., 2 for **£1.** 0·01 mfd MICA 2·5Kv, **£1** for 5, post 10p. Capacitor 0·125 mfd, 27,000 v. wkg. **£3·75** each, 50p post. 2·25 mfd 25 Kv. wkg. **£20** each, £3 carr.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps, **£2·50** each, carr. 75p.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 40 ohms at 2·6 amps; 500 ohms, 0·55 amps. Price (either type) **£2** each, 30p post each.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, **£4·50** each, carr. 75p.

AR88 RECEIVER: List of spares, **5p.**

TELEPRINTER EQUIPMENT, REPERFORATORS, READERS, and AUTO TRANSMITTERS ETC. Send for list, 5p.

T.M.S. OSCILLATOR UNIT C.F. NO. 1 MK. 2: 1 to 5000 cycles. 0 to 12 variable attenuator and switched 0-10-20-30-40 db with P.U.—12V d.c. 100-250V a.c. Price **£8.50,** Carr. £1.

REDIFON TELEPRINTER RELAY UNIT NO. 12: ZA-41196 and power supply 200-250V a.c. Polarised relay type 3SEITR. 80-0-80V 25mA. Two stabilised valves CV 286. Centre Zero Meter 10-0-10. Size 8in. × 8in. × 8in. New condition **£7.50,** Carr. 75p.

All U.K. orders subject to 10% Value Added Tax. This must be added to the total price (including postage or carriage).

If wishing to call at Stores, please telephone for appointment.

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RESISTORS—10%, 5%, 2%

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99	100 up
					(see note below)		
C	1/20W	5%	82Ω–220KΩ	E12	9	8	7·5
C	1/8W	5%	4·7Ω–470KΩ	E24	1	0·9	0·75 nett
C	1/4W	10%	4·7Ω–10MΩ	E12	1	0·9	0·75 nett
C	1/2W	5%	4·7Ω–10MΩ	E24	1·2	1	0·7 nett
C	1W	10%	4·7Ω–10MΩ	E12	2·5	2	0·5 nett
MO	1/2W	2%	10Ω–1MΩ	E24	4	3	2 nett
WW	1W	10%±1/20Ω	0·22Ω–3·9Ω	E12	7	7	6
WW	3W	5%	1Ω–10KΩ	E12	7	7	6
WW	7W	5%	1Ω–10KΩ	E12	9	9	8

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.
Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series. as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions on total value of resistor order.)

TRANSISTORS BY SIEMENS AND NEWMARKET

2N3055 npn silicon power **60p**
AC153K pnp germanium low power **23p**
AC176K npn germanium low power **32p**
AD161 npn germanium medium power **42p**
AD162 pnp germanium medium power **40p**
AF139 pnp germanium UHF **33p**
BC107—**13p**; BC108—**12p**; BC109—**13p**] npn
BC167—**10p**; BC168— **9p**; BC169—**10p**
BC177—**15p**; BC178—**14p**; BC179—**15p**] pnp
BC257— **9p**; BC258— **8p**; BC259— **9p**
Standard groupings available.

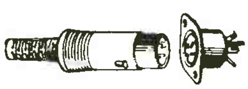
BD135 npn medium power **30p**
BD136 pnp medium power **33p**

DIODES
OA90, OA91, OA95 each **6p**
OA200—**9p**; OA202—**10p**

Other semi-conductors
AC128—**21p** AF117—**24p**
BFY51—**19p**

Very many other types listed, described and illustrated in catalogue.

DIN CONNECTORS by Hirshmann 4A rating

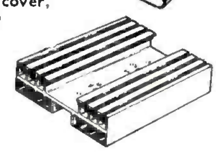


2 way loudspeaker	Socket	**10p**	Plug	**12p**
3 way audio	Socket	**10p**	Plug	**12p**
5 way audio 180°	Socket	**12p**	Plug	**15p**
5 way audio 240°	Socket	**12p**	Plug	**15p**
6 way audio	Socket	**13p**	Plug	**15p**

Lockable types, phono connectors, etc.

COVERS & HEATSINKS

T03 Transistor cover, clip-on **7p**
HEATSINK
Type 6W1 Extruded aluminium 1°C/W, undrilled **60p**



TOGGLE SWITCHES

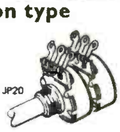
1011C SPST toggle **19p**; **409** DPDT toggle **28p**. (These are chrome plated, 2.5A rating). **7201** Sub-miniature DPDT 250V a.c./2A **48p**

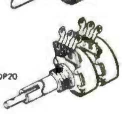
TTL ICs

			Nett Prise
FLH101	(7400)		20p
FLH201	(7401)		20p
FLH191	(7402)		20p
FLH291	(7403)		20p
FLH211	(7404)		25p
FLH271	(7405)		25p
FLH381	(7408)		25p
FLH391	(7409)		25p
FLH111	(7410)		20p
FLH351	(7413)		35p
FLH121	(7420)		20p
FLH131	(7430)		20p
FLH141	(7440)		24p
FLL101	(74141)	(16)	£1·22
FLH281	(7442)	(16)	£1·16
FLH361	(7443)	(16)	£1·45
FLH371	(7444)	(16)	£1·45
FLH151	(7450)		20p
FLH161	(7451)		20p
FLH171	(7453)		20p
FLH181	(7454)		20p
FLY101	(7466)		20p
FLJ101	(7470)		45p
FLJ111	(7472)		32p
FLJ121	(7473)		45p
FLJ141	(7474)		45p
FLJ151	(7475)	(16)	45p
FLJ131	(7476)	(16)	45p
FLH221	(7480)		68p
FLH231	(7482)		87p
FLH241	(7483)	(16)	£1·32
FLH341	(7486)		33p
FLJ161	(7490)		80p
FLJ221	(7491AN)		£1·28
FLJ171	(7492)		85p
FLJ181	(7493)		80p
FLJ231	(7494)	(16)	£1·13
FLJ191	(7495)		87p
FLJ261	(7496)	(16)	£1·48
FLJ301	(74100)	(24)	£1·64
FLJ281	(74104)		43p
FLJ271	(74107)		52p
FLK101	(74121)		48p
FLJ201	(74190)	(16)	1£·80
FLJ211	(74191)	(16)	£1·80
FLJ241	(74192)	(16)	£1·74
FLJ251	(74193)	(16)	£1·74

POTENTIOMETER carbon type

long spindles. Double wipers for low noise.
SINGLE GANG R20 linear 100Ω to 2·2MΩ, **12p**, JP20 Log, 4·7KΩ, to 2·2MΩ **12p.**
DUAL GANG linear 4·7KΩ to 2·2MΩ, **42p; Dual** gang log, 4·7KΩ to 2·2MΩ, **42p**; Log/antilog, 10K, 22K, 47K, 1MΩ only **42p**; Dual antilog, 10K only, **42p.** Any type with 2A D.P. mains switch, **12p** extra.
Only decades of 10, 22 & 47 available in ranges quoted.
DUAL CONCENTRIC DP20 in any combination of P20 values, **60p**; with switch, **72p.**


TYPE JP20


TYPE DP20

SLIDER POTS. In values from 4K7Ω to 1MΩ, linear or log, **26p each.** Escutcheon, light grey, **10p.** Knobs, flat, grip type, in 7 colour, **5p each.**
SKELETON PRE-SETS. Small high quality, type PR linear only: 100Ω, 220Ω, 470Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 470K, 1M, 2M2, 5M, 10MΩ. Vertical or horizontal mounting, **5p each.**
NUTS, SCREWS, ETC. In pence per 100.
Nuts 2BA—**51p**; 4BA—**35p**; 6BA—**32p.**
Screws 1″—2BA—**85p**; 4BA—**43p**; 6BA—**32p.** 0·5″—2BA—**62p**; 4BA—**29p**; 6BA—**24p.**
Screws roundheaded, cheese headed or countersunk. Other sizes available. Also tags, washers, spacers, etc.

ELECTROLYTICS

Prices in pennies

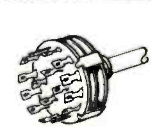
μF	3V	6.3V	10V	16V	25V	40V	63V	100V
0.47							7	7
1.0						7		7
2.2					7		7	7
4.7				7		7	7	7
10			7		7	7	7	7
22			7		7	7	7	7
47	7		7	7	7	7	8	12
100	7	7	7	7	7	8	12	18
220	7	7	7	8	9	10	17	26
470	7	8	9	9	12	17	24	41
1000	9	12	12	17	20	23	40	
2200	14	16	22	25	36	40		
4700	23	26	37	40				
10,000	37	40						

Smallest size 3·7mm x 12mm. Largest size 25·5mm x 41mm. Full ranges of many other types of capacitors stocked.

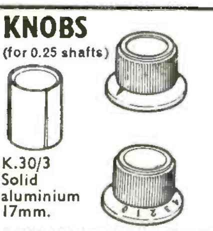
ROTARY SWITCHES

Radiospares Miniature Makaswitch (in assembly kit form). Shaft **48p.**
Wafers, MBB—2P5W, 1P 11W; BBM1P12W, 2P6W, 3P4W, 4P3W, 6P2W, each **32p.**

Wavechange switches 1P12W, 2P6W, 3P4W, 4P3W, each **32p.**



KNOBS
(for 0.25 shafts)

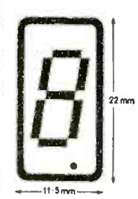


K.30/3 Solid aluminium 17mm.

F.14 skirt dia. 20mm. pack of 2 **32p**
F.13 skirt dia. 26mm. pack of 2 **38p**
F.12 skirt dia. 33mm. pack of 2 **40p**
F.19 engraved 20mm.—two **32p**
F.18 engraved. 26mm.—two **38p**
F.17 engraved. 33mm.—two **40p**
Very many other types in stock—see Catalogue.

KB.4 Ribbed Skirt dia. 20mm. 4 in pack. **40p**

Minitron DIGITAL INDICATOR



TYPE 3015F Seven segment indicator compatible with standard logic modules and power supplies. Figs. 0 9 from well illuminated filament segments to give character of 9mm height plus decimal point. Power requirement 8mA from 5V D.C. per segment. A limited number of alphabetical symbols also available. In 16 lead DIL case .. .. nett **£2·00**
Suitable BCD decoder driver type FLL121T nett **£1·36**
DIL Socket; 16 lead **30p. No. 3015G showing + or — and fig. 1 and decimal poin £2·00. nett**

DISCOUNTS
Available on all items except those shown with NETT PRICES. 10% on orders from £5 to £15. 15% on orders £15 and over.

TERMS OF BUSINESS
All items are offered for sale in accordance with our standard terms of business, a copy of which is available on request. Prices subject to alteration without notice. Enquiries from quantity users invited.

PACKING & POSTAGE FREE in U.K. For mail orders for £2 list value and under, there is an additional handling charge of 10p.

V.A.T
Prices shown here
DO NOT INCLUDE V.A.T.
Orders from U.K. customers must be accompanied by an additional 10% of nett value for V.A.T.
Overseas orders are exempt.

ZENER DIODES
Full range E24 values: 400m W: 2·7V to 36V, **14p each**; 1W: 6·8V to 82V, **21p each**; 1·5W: 4·7V to 75V, **48p each. Clip** to increase 1·5 W rating to 3 watts (type) 266F) **4p.**

SIEMENS THYRISTORS
0·8A 400V, **48p**; 600V **66p.**
3A 400V, **52p**; 600V, , **76p.**
DE-SOLDER BRAID
6ft. nett **50p**

S-DEC
Unsurpassed for "breadboard work" can be used indefinitely without deterioration. Components just push into plug holes and connect automatically. Slot for control panel. 70 holes. **£1·44.**

T-DEC
For more advanced work with 208 contacts in 38 rows. Will take one 16 lead carrier. **£2·88.** (Carriers supplied separately.)

MAINS TRANSFORMERS
MT3 30V/2A plus 4 taps **£2·85**
MT103 50V/1A plus 4 taps **£2·55**
MT104 50V/2A plus 4 taps **£3·50**
MT127 60V/2A plus 4 taps **£3·80**
13T05 13V/½A, CT **£1·25**
28T05 12+12; 2-0-2V/½A **£1·60**

IT SAVES YOU 25p TO START WITH
That's the price of the 96 page Electrovalue Catalogue (No. 6) and with it we give you a 25p refund exchange voucher on orders which come to £5 or more. The Catalogue is packed with bargains in brand new guaranteed to makers spec. items plus I.C. circuit and schematic diagrams, transistor diagrams and specs, equivalent tables etc. Send 25p (plus 2½p VAT when operative) for Catalogue by return.

ELECTROVALUE LTD
(DEPT. WW.3), 28 ST. JUDES RD, ENGLEFIELD GREEN, EGHAM, SURREY, TW20 0HB
Hours: 9-5.30, 1.0 p.m. Saturdays. ***Phone: Egham 3603 Telex 264475***
Reg. offices at above address Business Reg. No. 1047769

MULLARD AMP

Sensational 'Once in a Life-time Offer' Unrepeatable once stocks are cleared. The amplifier is made by Mullard. Carries maker's Gurantee. In neat case. May be used for Mono or Stereo. Music or speech. Works off dry battery, car batt. or mains power pack. FREE—all who purchase we send copy of Mullard booklet DIY stereo. £1·45

INTEGRATED CIRCUIT BARGAIN

A parcel of integrated circuits made by the famous Plessey Company. A once-in-a-lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first-grade device, definitely not sub-standard or seconds. 4 of the ICs are single silicon chip GP amplifiers, the 5th is a monolithic NPN matched pair. Regular price of parcel well over £5. Full circuit details of the ICs are included and in addition you will receive a list of many different ICs available at bargain prices 25p upwards with circuits and technical data of each. Complete parcel only £1 post paid.
DON'T MISS THIS TERRIFIC BARGAIN.

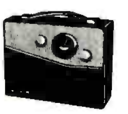
DRILL CONTROLLER

New 1kW model. Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions £1·50, plus 13p post and insurance. Made up model also available £2·25 plus 13p p. & p.

MIGHTY MIDGET

Probably the finest possible radio, as described in Practical Wireless, January 73. All electronic parts £2 post paid.

GOOD COMPANION I.C. VERSION



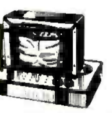
We can now offer these again in I.C. version using Ferranti ZN414 and Mullard AF Module 1172. Cabinet size approx. 11in. wide × 8in. high × 3in. deep. Complete assembly instructions, £5·75 plus 25p post and ins. Excellent tone wood cabinet.

I CHIP RADIO

Ferranti's latest device ZN414—gives results better than superhet. Supplied complete with technical notes and circuits £1·25 each. 10 for £11.

HI-Q TUNER COMPONENTS

For experimenting with the ZN414
Kit No. 1 Plessey Miniature Tuning Condenser with built in LW switch and 3in. Ferrit slab and litz wound MW coil 65p.
Kit No. 2 Air spaced tuning condenser 6in. ferrit rod litz wound MW and LW coils 85p.
Kit No. 3 Air spaced TC with slow motion drive 8in. ferrit rod with litz wound LW and MW coils £1.
Kit No. 4 Permeability tuner with fast and slow motion drive and LW loading coils. 45p.



12 VOLT 1½ AMP POWER PACK

This comprises double-wound 230/240V mains transformer with full wave rectifier and 2000 m/f/d smoothing. Price £2·00, plus 20p post & packing.

Heavy Duty Mains Power Pack. Output voltage adjustable from 15-40V in steps—maximum load 250W—that is from 6 amp at 40V to 15amp at 15V. This really is a high power heavy duty unit with dozens of workshop uses. Output voltage adjustment is very quick—simply interchange push on leads. Silicon rectifiers and smoothing by 3,000mF. Price £5·75 plus 65p post.

BALANCED ARMATURE UNITS

These Capsules are 1in. in diameter and ¼in. thick. They will operate as a microphone or loud speaker so can be used in intercom and similar circuits. 33p. Ten for £3.

MUSIC ON TAPE

A further buy enables us to offer these at an even lower price—namely 65p. each or 5 for £2·50. Send for list of titles. We can't repeat when sold out.

MICRO SWITCH

5 amp changeover contacts. 10p each. 10 for 90p. 15 amp. S.P Model 12p, changeover 15p. each

FLEX CABLE SNIP

3 core heavy circular T.R.S. waterproof flex, ideal for running down the garden to pool or shed. 1·5mm cores (5 amp) 100 yard coils £4·25 plus carriage 75p up to 200 miles. £1—300 miles. £1·50 —500 miles.

20 WATT INVERTER

Smart and Brown— For van lighting or camping, etc. Will light a 2ft. 20 watt standard fluorescent tube from a 12V car battery, current approx. 2A. Very well made unit using die cast chassis. Size 11½in. × 2in. × 1½in. Price £6·50 complete with lamp holders and tube clips.

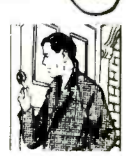
MAINS RELAY BARGAIN

Special this month are some single, double and treble pole changeover relays. Contacts rated at 15amps. Operating coil would for 240V. A.C. Good British Make. Unused Size approx. 1½ .. 1in. Open construction.
Single pole 25p each 10for £2·25
Treble pole 35p each 10 for £3·15

QUICK CUPPA

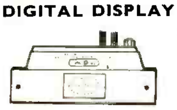
Mini Immersion Heater. 350W. 200/240V. Boils full cup in about two minutes. Use any socket or lamp holder. Have at bedside for tea, baby's food, etc. £1·25, post and insurance 20p. 12V car model also available. Same price. Jug model also available £1·50 plus P. & P. 20p.

DOOR INTERCOM



Know who is calling and speak to them without leaving bed, or chair. Outfit comprises microphone with call push button, connectors and master inter-com. Simply plugs together. Originally sold at £10. Special snip price £3·50 plus 20p postage.

DIGITAL DISPLAY



Panel mounting unit measuring approx. 3½in. × 1in. × 1½in. deep. Size of the display aperture is approx. 1½in. × 1in. Light up to 0-9. Ex equipment but unused and in perfect order. Price £1 each.

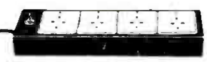
THYRISTOR LIGHT DIMMER

For any lamp up to 250 watt. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price £2·95. Industrial model 5A £3.

10 AMP DIMMER CONTROL

For the control of lighting on stage or in a studio or for control of portable equipment in workshops, etc. This has two 13 amp socket outlets each is controlled by a 5 amp solid state regulator. The overall length is 17in., width 3½in. and depth 1½in. In the end is fitted a master On/Off switch indicator, lamp and fuse. Price £7·50.

DISTRIBUTION PANELS



Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 6 feet of heavy cable. Wired up ready to work, £2·25 plus 25p P. & P.

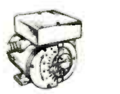
CAPACITOR DISCHARGE CAR IGNITION

This system which has proved to be amazingly efficient and reliable was first described in the *Wireless World* about a year ago We can supply kit of parts for an improved and even more efficient version (*Practical Wireless*, June). Price £4·95 plus 30p post. When ordering please state whether for positive or negative systems. Also available, ready made ignition systems for 6v. vehicles. £5·25 plus 20p.

CENTRIFUGAL BLOWER

Miniature mains driven blower centrifugal type blower unit by Woods, powerful but specially built for quiet running—driven by cushioned induction motor with specially built low noise bearings. Overall size of blower is approx. 4½" × 4½" × 4". When mounted by its flange air is blown into the equipment but to suck air out mount it from the centre using a clamp, ideal for cooling electrical equipment, or fitting into a cooker hood, film drying cabinet or for removing flux smoke when soldering etc., etc. A real bargain at £1·85.

ZPM MODULATION MOTOR

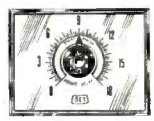


Could also be used to open ventilators, doors, valve, damper, etc. particularly suitable for remote control. Made by Satchwell. Essentially a reversible geared motor fitted with internal limit switches to stop it at the end of its travel. Size approx. 6in. × 6in. × 5½in. and weighing approx. 10 lb. This is extremely powerful and would lift a heavy door or open a long line of ventilators. To operate this motor you put the 50 cycle supply through a changeover switch. For instance a thermostat with changeover contacts could automatically regulate the temperature in a growing house, chicken hatchery, etc. An indicator on the motor graduated 0–10 shows the state of open or close. Also internally fitted is a variable resistor, wires from this to a volt meter would give a remote indication of the open or close position. A very expensive motor if both direct from Satchwell, our price complete with step down Transformer is £15.

CENTRIFUGAL FAN

Mains operated, turbo blower type. Pressed steel housing contains motor and impeller. Motor is 1/10th h.p. giving considerable air flow but virtually no noise. Approx. dimensions 10½ in. wide × 12 in. dia. outlet into trunking 10½ × 4½ in. £5·95 plus £1 post and insurance.

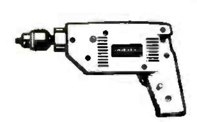
PROCESS TIME CONTROLLER



Made by Smiths. Motorised and mains driven in metal case with glass front and chrome surround. Covers a period of 18 hours. During this 18 hours the controlled device can be made to switch on for a period of 15 minutes to 3 hours. Probable cost from Smiths over £6. Special snip price £1·60 plus 20p post and insurance.

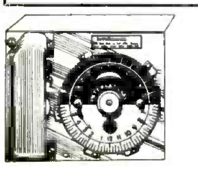
THIS MONTH'S SNIP

PORTABLE ELECTRIC DRILL



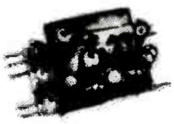
Very superior quality made by a famous Dutch Toolmaker. Model No. ASM830. 300w., 2 speed, 2,200 3,000. With $\frac{5}{16}$in. chuck and chuck key, also separate side handle and hammer facility for dealing with concrete etc. An equivalent British made drill would cost £15. £9·95. Similar model but without the hammer attachment £7·95. Have either on approval for 7 days.

ELECTRIC TIME SWITCH



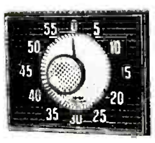
Made by Smiths these are A.C. mains operated. NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 amp changeover contacts will switch circuit on or off during these periods. £2·50 post and ins., 23p. Additional time contacts 50p pair.

MULLARD AUDIO AMPLIFIERS



All in module form. each ready built complete with heat sinks and connection tags, data supplied.
Model 1153 500mW power output 65p.
Model 1172 750mW power output 85p.
Model EP9000 4 watt power output £1·45.
EP9001 twin channel or stereo pre amp. £1·80.
10% discount if 10 or more ordered.

1 HOUR MINUTE TIMER



Made by famous Smiths company, these have a large clear dial, size 4½ in. × 3½ in., which can be set in minutes up to 1 hour. After preset period the bell rings. Ideal for processing, a memory jogger or, by adding simple lever, would operate micro-switch. £1·15.

DIGITAL COUNTER TIMER

Very stable and reliable crystal controlled circuit. Capable to work in excess of 15MHz. Construction simplified by use of 15 integrated circuits. Complete kit of parts £39·50 or construction data and price list 30p.

PP3 BATTERY CHARGER

almost 3 times the life can be obtained from PP3 battery if you re-charge it from the mains—this ready to use charger with instructions only 50p.

DOUBLE-ENDED MAINS MOTOR

This is a very quiet running induction motor, with two special features—one is that it has feet for easy fixing and the other is it has a good length of spindle coming from each end. So it could drive two things at once—or with simple slide attachment could reverse direction. 50p each or 10 for £4·50.

PROTECT VALUABLE DEVICES FROM THERMAL RUNAWAY OR OVERHEATING

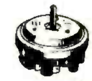
Thyristors, rectifiers, transistors, etc., which use heatsinks can easily be protected. Simply make the contact thermostat part of the heatsink. Motors and equipment generally, can also be adequately protected by having thermostats in strategic spots on the casing. Our contact thermostat has a calibrated dial for setting between 90deg. to 190deg.F, or with the dial removed range setting is between 80 to 800deg.F. Price 75p.

Where postage is not stated then orders over £5 are post free. Below £5 add 20p. S.A.E. with enquiries please.

TIME SWITCH

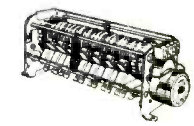
Smith's mains driven clock with 15 amp switch, also notes showing how you can wake up with music playing kettle boiling or come home to a warm house, warn off burglars, keep pets warm, halve your heating bill, etc. £1·95.

PRESSURE SWITCH



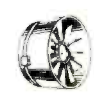
Containing a 15 amp. change over switch operated by a diaphragm which in turn is operated by air pressure through a small metal tube. The operating pressure is adjustable but is set to operate in approx. 10in. of water. These are quite low pressure devices and can in fact be operated simply by blowing into the inlet tube. Original use was for washing machines to turn off water when tub has reached correct level but no doubt has many other applications. £1·25.

HONEYWELL PROGRAMMER



This is a drum type timing device, the drum being calibrated in equal divisions for switch setting purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 changeover micro switches each of 10 amp type operated by the trips thus 15 circuits may be changed per revolution. Drive motor is mains operated 5 revs per min. Some of the many uses of this timer are Machinery control. Boiler firing. Dispensing and Vending machines. Display lighting animated and signs. Signalling, etc. Price from makers probably over £10 each. Special snip price £5·75 plus 25p post and insurance. Don't miss this terrific bargain.

EXTRACTOR FAN

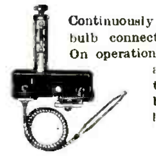


Cleans the air at the rate of 10,000 cubic ft. per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc., it's so quiet it can hardly be heard. Compact, 5½in. casing with 5½in. fan blades. Kit comprises motor, fan blades, sheet steel casing, pull switch, mains connector, and fixing brackets. £2 plus 36p post and ins.

IMMERSION HEATERS BY REMPLOY

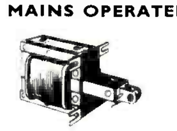
Standard fitting for domestic water tanks, made by the famous Remploy Company. Complete with sealing washers suitable for 200-240 volts A.C. Depth into tank 11in., 2kw. or 3kw. £1·50 plus 40p each post and insurance.

THERMOSTAT



Continuously variable 30°-90°C. Has sensor bulb connected by 33 in. of flexible tubing. On operation a 15 amp. 250V switch is opened and in addition a plunger moves through approx. ⅛ in. This could be used to open valve on ventilator etc. £1·50 plus 23p and ins.

MAINS OPERATED SOLENOIDS



Model 772—small but powerful 1in. pull—approx. size 1½ × 1½ × 1¼in., 60p.
Model 4001/—½in. pull. Size 2¼ × 2 × 1¾in. 75p.
Model TT1—1½in. pull. Size 3 × 2½ × 2in. £1·80 plus 20p. post and insurance.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only £1 plus 20p postage.

RECORD/PLAYBACK HEADS (TRUVOX)

Individual prices are: 2 track record/playback heads 45p each. 4 track record/playback heads 65p each. Erase heads are also available separately: 2 track 15p; 4 track 25p.

16 TRACK STEREO HEAD

For ¼in. or 1in. tape. This is a brass encased tape head and measures approx. ¾in. × ½in. × ¾in. Resistance is approx. 20-0-20 ohms. These heads are beautifully made but we have no technical data, also only have a limited quantity. Price £5 each or 10 for £45.

CONNECTING WIRE

7·0076 Copper conductors. 500 metre drums available in the following colours: Red/Brown, Yellow, Green/Grey, Blue/Green, Red/Orange, Green/White, Grey/White, Blue/Orange, Brown/Red, Brown/White. Red/Grey, Blue/Grey, Blue/Brown. Price £2 per drum plus 40p post. State alternative colours. Ditto but with 200 metres. Price £1·25 per drum plus 20p. Ditto but with 100 metres. Price 75p per drum.

GOODMANS P.M. SPEAKERS

8in. × 5in. hi flux 15 ohm coil very suitable for use with Mullard Unilex stereo amplifier or with the EP9000 on its own £1·50 plus 20p post each.

7in. × 4in., also 15 ohm and suitable for use with EP9000 not quite such good quality of course. Price 95p each.

SOIL HEATING KIT

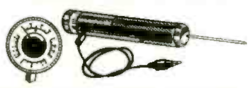
Suitable for garden frame or propogating shelf, etc. Comprises 40 watt mains transformer, heating wire, connection strip and insulated wire with connection diagram. £1·50 plus 20p post.

PLEASE ADD 10% V.A.T. TO ALL PRICES

J. BULL (ELECTRICAL) LTD.
(Dept. W.W.) 7, Park Street, Croydon, CR0 1YD
Callers to 102/3, Tamworth Road, Croydon

GWS G.W.SMITH & CO (RADIO) LTD

ROUND SCALE TYPE PENCIL TESTER MODEL TS.68

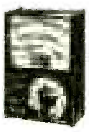


Completely portable, simple to use pocket sized tester. Ranges: 0/3/30/300v A.C. and D.C. at 2,000 o.p.v. Resistance 0-20K ohms. Only **£1·97**. Post 13p.

TS60 POCKET MULTIMETER

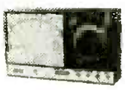
High-precision at low-cost. Ranges: D.C. 15V., 150V., 1,000V. (10,000 opv). A.C. 15V, 150V., 1000V. (1,000 opv). D.C. Current 150mA. Resistance 100k/ohms. £1·85. Post 15p.

MODEL 1092 TESTMETER



5,000 O.P.V.
0/3/15/150/300/1200 V. D.C.
0/6/30/300/600 V. A.C.
0/300µA/300 MA
0/10K/1 meg Ω
Decibels —10 to +16 db
£2·75 each. Post 15p.

LT601 MULTIMETER

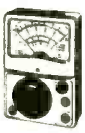


New style 20,000 o.p.v. pocket multimeter. 5 / 25 / 50 / 250 / 2500V. D.C. 10/50/100/500/1000V. A.C. 50µA/250mA. 6K/6 meg ohms. —20 to +22db. **£3·75**. Post 20p.

MODEL TE-200

20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000V. D.C. 0/10/50/250/1,000V. A.C. 0/50 µA/250 mA. 0/60K/6 megΩ. —20 to +62 db. **£3·95**. Post 15p.

HIOKI MODEL 720X



20,000 O.P.V. Overload protection 5/25/100/500/1000 VDC. 10/50/250/1000 VAC. 50µA/250 mA. 20K/2 meg ohm. —5 to +62db. **£4·97**. Post 15p.

MODEL TH-12

20,000 o.p.v. Overload protection. Slide switch selector. 0/·25/2·5/10/50/250/1000V. D.C. 0/10/50/250/1000V. A.C. 0/50µA/25/250mA D.C. 0/3K/30K/300K/3 meg. —20 to +50db. **£4·97**. Post 15p.

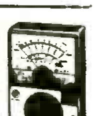
MODEL TE-300

300,000 O.P.V. Mirror scale, overload protection 0/.6/3/15/60/300/1,200 V.D.C. 0/6/30/120/600/1,200 V.A.C. 0/30µA/6mA/6 OmA/300mA/600mA. 0/8K/80K/800K/8 meg. —20 to +63 db. **£5·97**. Post 15p.

RUSSIAN 22 RANGE MULTIMETER

Model U437 10,000 o.p.v. A first class versatile instrument manufactured in U.S.S.R. to the highest standards. Ranges: 2·5/10/50/250/500/1000v D.C. 2·5/10/50/250/500/1000v A.C. D.C. Current 100 wA/1/10/100 mA/1A. Resistance 300 ohms/3/30/300K/3MΩ. Complete with batteries, test leads, instructions and sturdy steel carrying case.
Our Price **£5·97**. Post 25p.

HIOKI MODEL 730X



30,000 O.P.V. Overload protection. 6/30/60/300/600/1200 VDC. 12/60/120/600/1200 VAC. 60 µA/30 mA/300 mA. 2K/200K/2 megohm. —10 to +63 db. **£6·50**. Post 15p.

MODEL PL536

20kΩ/Volt D.C. 8kΩ/Volt A.C. Mirror scale. ·6/3/12/30/120/600V D.C. 3/30/120/600V A.C. 50/600µA/60/600 mA. 10/100K/1 Meg/10 meg Ω.—20 to +46db. **£6·97**. Post 12p.

TMK MODEL TW-50K

46 ranges, mirror scale, 50K/Vol. D.C. 5K /Volt A.C. D.C.: Volts ·125, ·25, 1·25, 2·5, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.C. Volts: 1·5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.C. Current: 25, 50µA, 2·5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance: 10K, 100K, 1 MEG, 10 MEGΩ. Decibels: —20 to +81·5 db. **£8·50**. Post 17p.

MODEL 500

30,000 O.P.V. with overload protection, mirror scale. 0/·5/2·5/10/25/100/250/500/1,000 v. D.C. 0/2.5/10/25/100/250/500/1,000 v. A.C. 0/50µA/5/50/500 mA. 12 amp. D.C. 0/60/K/6 meg/60 meg Ω.
£8·87. Post paid.

MODEL K228A

Taut band suspension. Overload protection. Polarity reversing switch. 30,000 o.p.v. 50/0/·5/2·5/15/250/500/1000/2500V D.C. 0/15/50/150/500/1000V. A.C. 0/50µA/5/50/150/500mA/5A D.C. /0/3K300K/3 meg. £8·95. Post 20p.

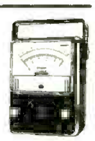
HIOKI MODEL 750X

50,000 o.p.v. 43 ranges 0-0.3 to 1,200v. D.C. 0-3 to 1,200 v. A.C. 0-30µA/300mA. 0-3K/30 meg. ohms. —10 to +17 db. £8·97. Post 20p.

U4312 MULTIMETER

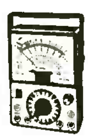
Extremely sturdy instrument for general electrical use. 667 o.p.v. 0/·3/1·5/7·5/30/60/150/300/600/900 VDC and 75mV. 0/·3/1·5/7·5/30/60/150/300/600/900 VAC. 0/300µA/1·5/6/15/60/150 600MA/1·5/6 AMP. D.C. 0/1·5/6/15/60/150/600MA/1·5/6 AMP. A.C.0/200 Ω/3K/30K Ω. Accuracy DC 1%. AC 1·5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions. **£9·50**. Post25p.

HT100B4 MULTIMETER



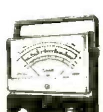
Features A.C. current ranges. 100,000 o.p.v. Mirror Scale, Overload protection. 0/·5/2·5/10/50/250/500/1000 V DC. 0/2·5/10/50/250/1000 V AC. 0/10/250MµA/2·5/25/250 MA/10 Amp DC. 10 Amp AC. 0/20K/200K/2MEG/20MEG. — 20 + 62 db. **£12·50**. Post 25p.

HAOKI MODEL 700X



100,000 O.P.V. Overload protection. Mirror scale, ·3/·6/1·2/1·5/3/6/12/30/60/120/300/600/1200 VDC. 1·5/3/6/12/30/60/150/300/600/1200 VAC. 15/30vA/3/6/30/60/150/300 mA. 6/12 AMP DC. 2K/200 K/2 Meg/20 megohm. —20 to +63db. **£13·50**. Post 20p.

MODEL C-7080 EN



Giant 6in. mirror scale. 20,000 o.p.v. 0/·25/1/2·5/10/50/250/1000/5000V. D.C. 0/2·5/10/50/250/1000/5000V. A.C. 0/50µA/1/10/100/500mA/10 amp. D.C. 0/2K/200K/20 meg. —20 to +50 db. £13·95. Post 35p.

370 WTR MULTIMETER

Features A.C. current ranges. 20,000 o.p.v. 0/·5/2·5/10/50/250/500/1000 V DC. 0/2·5/10/50/250/500/1000 V AC. 0/50µA/1/10/500MA/1/10 Amp DC. 0/100MA/1/10 Amp AC. 0/5K/50K/500K/5MEG/50MEG. — 20 + 62 db. **£15**. Post 25p.

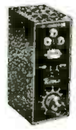
KAMODEN 72.200 MULTITESTER

High sensitivity tester. 200,000 o.p.v. Overload protection. Mirror scale. Ranges: 0/·06/·3/3/30/120/600/1200V. D.C. 0/3/12/60/300/11,20CV A.C. 0/6µA/1·2mA/120mA/600mA/12A. D.C. 0/12A. A.C. —20 to +63dB. 0/2K/200K/2 meg/200 meg ohms. **£16·95**. Post 30p.

MODEL S-100TR MULTIMETER/ TRANSISTOR TESTER

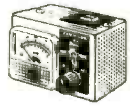
100,000 o.p.v. MIRROR SCALE/OVERLOAD PROTECTION.
0/·12—·6/3/12/30/120/600 V DC.
0/6/30/120/600 V. AC.
0/12/600uA/12/300MA/12 Amp. DC.
0/10K/1 MEG/100 MEG.
—20 to + 50 db. 0·01 —·2 mfd.
Transistor tester measures Alpha, beta and Ico. Complete with batteries, instructions and leads. **£13·50**. Post 25p.

LB4 TRANSISTOR TESTER



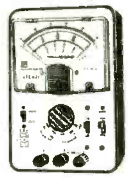
Tests PNP or NPN transistors. Audio indication. Operates on two 1.5v batteries. Complete with all instructions etc. **£4·50**. Post 20p.

LB3 TRANSISTOR TESTER



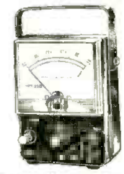
Tests ICO and B. PNP/NPN. Operates from 9v. battery. Complete with all instructions etc. **£3·95**. Post 20p.

FTC-401 TRANSISTOR TESTER



Full capabilities for measuring A, B and ICO. NPN or PNP. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads. **£7·50**. Post 20p.

KAMODEN HM.350 TRANSISTOR TESTER



High quality instrument to test Reverse Leak current and DC current Amplification factor of NPN, PNP, transistors, diodes, SCR's etc. 4in. × 4½in. clear scale meter. Operates from internel batteries. Complete with instructions leads and carrying handle. **£12·50** Post 30p.

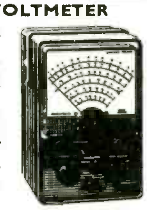
MODEL 449A IN CIRCUIT TRANSISTOR TESTER

Checks true A.C. beta in/out. Checks Icbo. Checks diodes in/out. Checks SCR etc. Beta HI 10-500. LO2-50. Icbo 0-5000µA. 220/240V. A.C. operation. **£17·50**. Post 25p. Icbo 0-5000µA. 220/240V. A.C. operation £17·50. Post 25p.

MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER

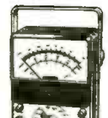
Sensitivity 330 ohms/Volt A.C. and D.C. Accuracy ·5% D.C. 1% A.C. Scale length 165mm. 0/300/750µA/1·5/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 Amp. D.C. 0/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 Amp. A.C. 0/75/150/300/750mV/1·5/3/7·5/15/30/75/150/300 750V. D.C. 0/750mV/1·5/3/7·5/15/30/75/150/300/650V. A.C. Automatic cut out. Supplied complete with test leads, manual and test certificates. £49. Post 50p

TE-65 VALVE VOLTMETER



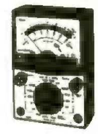
High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation Complete with probe and instructions. **£17·50**. Post 30p. Additions. Probes available: R.F. **£2·12** H.V. **£2·50**.

KAMODEN HM.720B F.E.T. V.O.M.



Input impedance 10 meg. ohms. Ranges: 0/·25/1/2·5/10/50/250/1000V, D.C. 0/2·5/10/50/250/1000V. A.C. 0/25µA/2·5/25/250 MA D.C. —20 to +62dB 0/5K/50K/500K/5 meg/500 meg ohms. **£14·95**. Post 30p.

MODEL L-55 FET V.O.M.

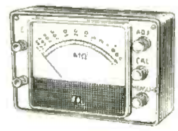


Input impedance 10 meg. ohms. 0/·3/1·2/6/30/120/600V. D.C. 0/3/12/60/120/600V. A.C. 0/120µA/120mA. D.C. 0/1K/100K/10 meg/100 meg ohms. **£15·97**. Post 25p.

HONEYWELL DIGITAL VOLTMETER VT.100

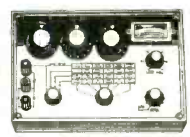
Can be panel or bench mounted. Basic meter measures 1 volt DC, but can be used to measure a wide range of AC and DC volt, current and ohms with optional plug in cards. Specification: Accuracy: ± 0·2, ± 1 digit. Resolution: 1 mV. Number of digits: 3 plus fourth overrange digit. Overrange: 100% (up to 1·999). Input impedance: 1000 Meg ohm. Measuring cycle: 1 per second. Adjustment: Automatic zeroing, full scale adjustment against an internal reference voltage. Overload: to 100v. D.C. Input: Fully floating (3 poles). Input power: 110-230v. A.C. 50/60 cycles. Overall size: 5⅛in. × 2 13/16in. × 8 3/16in. AVAILABLE BRAND NEW AND FULLY GUARANTEED.
£35.50 Carr. 50p.

KAMODEN HMG-500 INSULATION RESISTANCE TESTER



Range 0-1000 Megohms. 500 Volt. Battery operated. Wide range clear meter 4½in. × 4in. Complete with de luxe carrying case, batteries, instructions. **£19·95**. Post 30p.

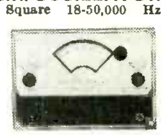
TRANSISTORISED L.C.R. A.C. MEASURING BRIDGE



A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1µH—111 HENRIES. 6 Ranges — 2%. C. 10PF±1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100µA. Meter indication. Attractive 2 tone metal case. Size 7½" × 5" × 2". **£20**. Post 25p.

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR

Sine 18-200,000 Hz; Square 18-50,000 Hz

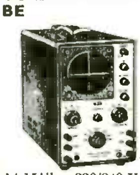


Output max. + 10 dB (10 K ohms). Operation internal batteries. Attractive 2-tone case 7½in. × 5in. × 2in. Price **£17.50** Carr. 17p.

CI-5 PULSE OSCILLOSCOPE

For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth 10MHz. Sensitivity at 100KHz VRMS/mm. .1-25; HOR. AMP. Bandwidth 500KHz. Sensititivy at 100KHz, V RMS/mm. .3-25; Preset triggered sweep 1-3,000µsec.; free running 20-200,000Hz in nine ranges. Calibrator pips. 220 × 360 × 430mm. 115-230V. A.C. operation. £39·00. Carr. paid.

TO-3 PORTABLE OSCILLOSCOPE 3in. TUBE



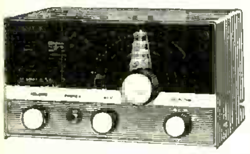
Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps —1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook **£47·50**. Carr. 50p.

RUSSIAN CL-16 DOUBLE BEAM OSCILLOSCOPE

5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. × 4in. C.R.T. Calibrated triggered sweep from ·2 µ/sec. to 100 milli-sec. per cm. Free running time base 50 c/s-1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. £87 Carr. paid.

GWS G.W.SMITH & CO (RADIO) LTD

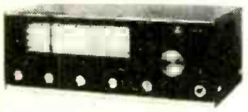
UNR 30 RECEIVER



4 Bands covering 550 kc/s-30 mc/s. B.F.O. Built-in Speaker 220/240 v. A.C. Brand new with instructions.

OUR PRICE **£15·75** Carr. 37p

UR-1A RECEIVER



4 Bands covering 550 kc/s-30 mc/s. FET, S Meter. Variable BFO for SSB. Built-in Speaker, Bandspread, Sensitivity Control. 220/240 v. A.C. or 12 v. D.C. 12¾in. × 4¾in. × 7in. Brand new with instructions.

OUR PRICE **£25·00** Carr. 37p

SKYWOOD CX203 RECEIVER

Solid state. 5 bands covering 200-420 KHz and ·55 to 30 MHz. Illuminated slide rule dial. Bandspread. Aerial tuning. BFO, AVC, ANL, "S" meter. AM/CW/SS B. Integrated speaker and phone socket. 220/240 v. A.C. or 12 v. D.C. Size 325 × 266 × 150 mm. Complete with instructions and circuit.

OUR PRICE **£32·50** Carr. 50p

LAFAYETTE HA-600 RECEIVER

General coverage 150-400 kc/s. 550 kc/s-30 mc/s. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, S Meter Bandspread. RF Gain. 15in. × 9¾in. × 8¼in. 18 lb. 220/240 v. A.C. or 12 v. D.C. Brand new with instructions.

OUR PRICE **£50·00** Carr. 50p

TRIO 9R59DS RECEIVER

4 bands covering 550 kc/s to 30 mc/s continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW. ANL. Variable BFO. S meter. Sep. bandspread dial. IF frequency 445 kc/s. audio output 1.5w. Variable RF and AF gain controls 115/250 v, A.C. Size: 7in. × 13in. × 10in. with instruction manual.

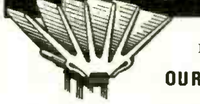
OUR PRICE **£49·50** Carr. Paid.

FULL TRIO RANGE STOCKED.

GWS

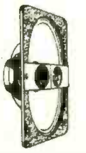
ALSO SEE PREVIOUS PAGES

SINCLAIR IC-12



List price £2·98.
OUR PRICE £1·80
Post 10p.

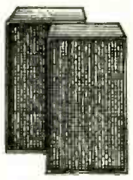
EMI LOUDSPEAKERS



Model 350. 13in. × 8in. with single tweeter/crossover. 20-20,000 Hz. 15 watt RMS. Available 8 or 15 ohms. £7·25 each. P. & P. 37p.
Model 450. 13in. × 8in. with twin tweeters/crossover. 55-13,000 Hz. 8 watts RMS. Available 8 or 15 ohms. £3·62 each. P. & P. 25p.

SPECIAL OFFER!

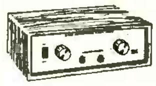
STEREO SPEAKERS



Matched pair of bookshelf speakers. De luxe teak veneered finish. Size 14¼in. × 9in. × 7¼in. 8 ohms. 8 watts RMS. 16 watts peak. Complete with DIN lead.

OUR PRICE **£12·95** Carr. 50p

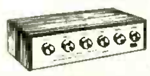
HA-10 STEREO HEADPHONE AMPLIFIER



All silicon transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9 v. battery. Inputs 5MU/100MU. Output 50MW.

OUR PRICE **£5·97** P. & P. 20p

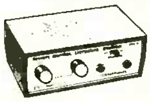
MP7 MIXER PREAMPLIFIER



5 microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. 9¼" x 5" x 3". Inputs Mics: 3 x 3mV 50K; 2 x 3mV 600 ohm. Phono meg. 4 mV 50K. Phono ceramic 100mV 1 meg. Output 250mV 100K.

OUR PRICE **£8·97** P. & P. 20p

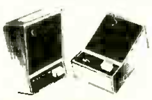
1021 STEREO LISTENING STATION



For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. 2 gain controls, speaker on-off slide switch, stereo headphone sockets. 6in. × 4in. × 2¼in.

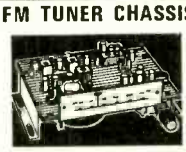
OUR PRICE **£2·25** P. & P. 20p

HOMER INTERCOMS



Ideal for home, office, stores, factories, etc. Supplied complete with batteries, cable and free instructions.
2 Station £2·97. P. & P. 15p.
3 Station £5·25. P. & P. 15p.
4 Station £6·62. P. & P. 17p.

FM TUNER CHASSIS



6 TRANSISTOR HIGH QUALITY TUNER. SIZE ONLY 6in. × 4in. × 2½in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money.

OUR PRICE **£5·95** P. & P. 20p

Stereo Multiplex Adaptor £4·97.

SH628 STEREO HEADPHONES

Outstanding value. Soft earpads, adjustable headband. 8-16 ohms. 20-20,000 Hz. Complete with lead and stereo plug.

OUR PRICE **£1·87** P. & P. 30p

SDH8V MONO/STEREO HEADPHONES

Two way stereo/mono with volume controls. Padded headband. 4-16 ohms. 20-18,000 Hz. Complete with lead and stereo plug.

OUR PRICE **£3·97** P. & P. 30p

BH001 HEADSET AND BOOM MICROPHONE

Moving coil. Headphone imp. 16 ohms. Mike imp. 200 ohms. Ideal for language teaching, communications etc. Complete with leads and plugs.

OUR PRICE **£4·62** P. & P. 30p

DH.08S Stereo Headphones

De luxe model with unique 2 way mechanical units and volume controls. 8 ohms. 20-20,000 Hz. Complete with coil lead and stereo jack plug.

OUR PRICE **£7·97** P. & P. 30p

ROTEL BARGAIN!

RH700 STEREO PHONES

Soft leather ear cushions. Impedance 8-16 ohms. 20-20,000 Hz. 15ft. coiled lead. Brand New and boxed. (List £9.95).

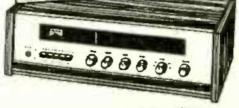
OUR PRICE **£6·75** P. & P. 30p

G.W.S. KDB3 DOLBY SYSTEM NOISE REDUCTION UNIT

Improves the performance of cassette and semi-professional recorders. Reduces tape hiss by 3 dB at 600 Hz, 6 dB at 1200 Hz and 10 dB for all frequencies above 3000 Hz. Controls for input levels and noise reduction on record and replay. 2 meters for Dolby level. Off tape monitoring. Frequency response: 20 Hz to 15 KHz+1 dB. 19 KHz−35 dB. Size 15¾in. × 9in. × 3¼in. AC 200/250 V.

OUR PRICE **£32·50** P. & P. 50p

ROTEL BARGAINS!

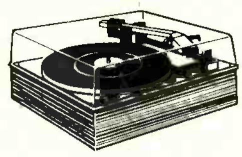


AM/FM STEREO RECEIVERS

RX150 7½+7½ watt	£36·95
RX200 10+10 watt	£46·50
RX400 20+20 watt	£57·50

P. & P. 75p.

RECORD DECK PACKAGES



Carriage and Packing 75p

Complete units with Stereo cartridge ready wired in plinth cover.

GARRARD	
2025 TC/9TAHCD	£10·65
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SP25 111/M44E	£16·75
SP25 111/M44-7	£16·75
SP25 111/M55E	£18·25
SP25 111 Module/M75-6	£18·99
AP76/G800	£23·95
AP76/G800E	£25·95
AP76/M44E	£24·95
AP76/M55E	£26·25
AP76/M75ED	£31·70
AP76/M75EJ	£27·85
AP76 Module M75-6	£26·95
AP96 Module M75-6	£30·40
ZERO 100S Module/M93E	£41·85
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210/SC7M	£6·85
MP60/G800	£15·50
MP60/TPD1/G800	£15·20
MP60/M44-7	£16·75
HT70/TPD1/G800	£18·60
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GL75/G800	£34·10
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LEAK	
Delta/M75-6	£43·95
PHILIPS	
GA105/GP200	£13·80
GA160/GP200 Teak	£20·00
GA212/GP400	£45·25
PIONEER	
PL12D (Less cartridge)	£29·60
PL15C (Less cartridge)	£41·25
PL41D (Less cartridge)	£95·25
PL50 (Less cartridge)	£89·90
PL61	£102·75
PLA35	£68·60
THORENS	
TD160C/Ortofon M15E Super	£62·50
TD125 AB/11/Ortofon M15E Super	£96·95
WHARFEDALE	
Linton/M44-7	£23·70

SINCLAIR PROJECT 60 PACKAGE DEALS

2 × Z30 Stereo 60/P/Z5 £15·95. P. & P. 37p.

2 × Z30/Stereo 60/PZ6 £18·00. P. & P. 37p.

2 × Z50/Stereo 60/PZ8 £20·25. P. & P. 37p.

Transformer for PZ8 £2·97 extra.

Active Filter Unit £4·45 extra.

Pair of Q16 Speakers £10·70 extra.

Sinclair Project 605 £20·97. P. & P. 37p.

HANIMEX HRC 3061 CASSETTE RADIO

Record/Playback facilities plus slide rule tuning of AM 535-1620 KHz and FM 88-108 MHz. Slider volume controls. Built in condenser microphone plus separate hand/desk microphone. Telescopic aerial. Complete with earpiece, batteries and instructions. (Tape not supplied.) (Rec. List price £ ·).

OUR PRICE **£22·75** P. & P. 50p

RECORD DECKS

Carriage & Packing 50p

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C114 Mini	£3·95
C129 Mono	£5·50
C137	£7·00
510/TPD1	£13·95
610	£9·90
610/TPD1	£14·85
710	£19·20
810	£24·50
710/810 Plinth and Cover	£8·35
MP60	£7·65
MP60/G800	£10·25
MP60/TPD1	£12·60
MP60/TPD2	£11·25
HT70	£10·97
HT70/G800	£13·60
HT70/TPD1	£15·95
CONNOISSEUR	
BD1 Kit	£8·65
BD1 Chassis	£10·75
BD1/SAU2/Plinth/Cover	£26·15
BD2/SAU2/Chassis	£21·15
BD2/SAU2/Plinth/Cover	£26·75
GARRARD	
2025 T/C Stereo	£6·40
SP25 III	£8·50
SP25 III/Acos GP104 Ceramic	£8·50
SP25/M75-6	£13·90
AP76	£15·55
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SL72B	£17·75
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401	£23·50
ZERO 100A	£30·30
ZERO 100S	£27·95
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G99	£16·85
G101P/C	£16·85
GL69/2	£15·75
GL72	£17·85
GL72/P	£23·20
Plinth 69/72	£5·35
LID 72	£2·70
GL75	£23·75
GL75P	£29·30
Plinth 75	£5·55
LID 75	£2·97
GL85P/C	£49·50
MICRO-SEIKI	
MR111	£24·90
MR111 Plinth and Cover	£8·25
THORENS	
TD125/II	£52·15
TD125AB/II	£78·55
TX25	£5·60
TD150A/II	£29·25
TD160C	£43·95

PLINTHS AND COVERS

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Budget AP76/Zero 100S	£3·95
Budget B.S.R.	£2·95
Garrard WB1	£2·20
Garrard SPC1	£2·20
Garrard WB4	£3·25
Garrard SPC4	£2·55
SME2000 System	£26·40

ROTEL BARGAINS!

RA10 8+8 watt	£22·50
RA310 15+15 watt	£34·95
RA610 32+32 watt	£51·95
RA810 40+40 watt	£72·95
RA1210 60+60 watt	£89·95

P. & P. 50p. extra.

LOW NOISE TAPE CASSETTES

Top quality in library cases.

	5	10	25
C60	£1·29	£2·53	£5·99
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Tape Head Cleaner 30p each.

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GXC40D Deck	£57·75
GXC40 Recorder	£67·95
GXC40T Deck/Receiver	£101·25
GXC45 Deck	£78·25
GXC46D Dolby Deck	£84·30
GXC46 Recorder	£90·75
GXC60D Deck	£87·65
GXC65D Dolby Deck	£93·40
CARTRIDGE (P. & P. 50p)	
CR81 Deck with amps.	£66·20
CR81D Deck	£54·10
CR81T Recorder/Receiver	£93·70
CR80SS 4 channel Recorder	£114·25
CR80DSS 4 channel Recorder	£94·95
TAPE (P. & P. 75p)	
4000DS Deck	£59·95
4000DS Dust Cover	£3·95
1721L Recorder	£60·35
X5000 Recorder	£82·50
X201D Deck	£108·20
GX220D Deck	£123·95
GX221D	£138·40
GX280D Deck	£196·50
GX370 Deck	£211·50
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GX1900D Deck	£144·50
TAPE/CARTRIDGE (P. & P. 75p)	
X1810D Deck	£138·40
TAPE/CASSETTE/CARTRIDGE (P. & P. 75p)	
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AA6200 20+20 watt	£61·95
AA8030 25+25 watt	£92·50
AA8080 40+40 watt	£117·50
AA8100S 2×36 or 4×18 watt	£175·00
AA8500 65+65 watt	£150·50
STEREO AMPLIFIERS (P. & P. 50p)	
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AA5500 30+30 watt	£78·50
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AT580 AM/FM	£94·50
4-CHANNEL UNIT (P. & P. 50p)	
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BSR 8 TRACK BARGAINS!

TD8S STEREO TAPE CARTRIDGE DECK
Connects to most stereo amplifiers (output 125 mV). Automatic/Manual programme selector.

OUR PRICE **£12·75** P. & P. 50p

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SPECIAL OFFER OF NEAT EQUIPMENT
(Buy now while stocks last).

PICK UP BARGAIN!

NEAT G30J

Identical specification to Neat G30 static balance arm but two-tone chrome and black finish. Complete with head shell, pick up rest and plug-in phono leads. Brand new and fully guaranteed.

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Neat V70 Cartridge (Bulk Pack)	£1·50
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P. & P. 12p extra.

AKAI BARGAINS!

AA6300 AM/FM STEREO TUNER AMPLIFIER

20+20 watts rms. Magnetic, ceramic and tape inputs. FM 88-108 MHz. AM 535-1605 kHz. Dual stereo speaker outputs. Headphone socket. (Rec. List Price £117.46).

OUR PRICE **£61·95** P. & P. 75p

FANTASTIC OFFER!

AKAI CS35D STEREO CASSETTE DECK

High quality 4 track record/playback deck. Accepts chrome/regular tape cassettes. Two VU meters and slider controls for recording level. Photo/Din output/input sockets. Headphone socket for monitoring.

OUR PRICE **£44·95** P. & P. 50p

UNREPEATABLE OFFER!

NIKKO TRM50 STEREO AMPLIFIER

17+17 watts rms. Inputs for magnetic and crystal phono, tuner, tape etc. Dual stereo speaker outputs. Headphone socket. Full range of controls. (Rec. List Price £59·50.)

OUR PRICE **£39·95** P. & P. 50p

KOSS BARGAIN!

SP3XC STEREO PHONES

Extremely sensitive high quality headphones.

Impedance 4-16 ohms. 10-15,000 Hz. Soft sponge ear cushions. 10ft. coiled lead. Brand new and boxed. (List £9·50.)

OUR PRICE **£6·50** P. & P. 30p

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MONATONE 6750 SYSTEM

AM/FM 4+4 watt stereo tuner amplifier. Garrard 2025 T/C, plinth and cover, stereo cartridge, pair of matching speakers and all leads.

OUR PRICE **£30·50** Carr. £1·00

ROTEL RA210 SYSTEM

8+8 watt amplifier, BSR MP60, plinth and cover, G800 cartridge, pair of Medway T138 speakers and all leads.

OUR PRICE **£54·40** Carr. & Ins. £1·25

ROTEL RX150 SYSTEM

AM/FM 7½+7½ watt stereo tuner amplifier, BSR MP60, plinth and cover, G800, pair of Denton 2 speakers and all leads.

OUR PRICE **£76·50** Carr. & Ins. £1·25

TRIO KA 2000A SYSTEM

16+16 watt amplifier, BSR MP60, plinth and cover, G800 cartridge, pair of Denton 2 speakers and all leads.

OUR PRICE **£70·95** Carr. £1·25

Matching KT 1000A AM/FM Stereo Tuner £43·75.

TELETON SAQ206B SYSTEM

8+8 watt amplifier, BSR MP60, plinth and cover, G800 cartridge, pair of Apollo speakers and all leads.

OUR PRICE **£51·50** Carr. £1·50

NIKKO TRM50 SYSTEM

17+17 watt amplifier, Garrard AP76, plinthand cover, G800E cartridge, pair of Linton 2 speakers and all leads.

OUR PRICE **£93·95** Carr. £1·25

AUDIOTRONIC LA.1700 SYSTEM

17+17 watt amplifier, Garrard AP76, plinth and cover, G800 cartridge, pair of Wharfdale Linton 2 speakers and all leads.

OUR PRICE **£86·95** £1·50 Carr. & Ins.

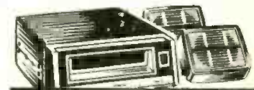
Matching LT1700 AM/FM Stereo Tuner £37·50.

AUDIOTRONIC LA.4000 SYSTEM

40+40 watt amplifier, Goldring GL75, plinth and cover, G800E cartridge, pair of Wharfdale Dovedale 3 speakers and all leads.

OUR PRICE **£152·95** Carr & Ins. £2·00

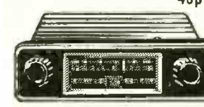
AUDIOTRONIC PRODUCTS



ACP-8 8 TRACK CAR PLAYER

Attractive black and silver finish. 12v neg. earth. Slider controls for Volume, Tone and Balance. Channel selector button with red pilot lamp. Complete with speakers, mounting brackets and instructions.

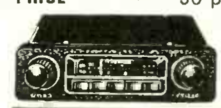
ONLY **£12·50** P & P 40p



ACR 3500 CAR RADIO

Manual tuning of Medium and Long waves. 12v pos. or neg. earth. Complete with speaker, mounting brackets and instructions.

OUR PRICE **£6·50** P & P 50 p

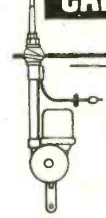


ACR1 PUSH BUTTON CAR RADIO

Push button tuning of one LW and five MW stations of your choice. 12v pos. or neg. earth. Complete with speaker, mounting brackets and instructions.

OUR PRICE **£8·95** P & P 50p

ACA 5SE ELECTRIC CAR AERIAL



5 section. Fully automatic. 12v DC. Extends to approx. 40". Complete with switch, all leads and instructions.

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257, Tottenham Ct. Rd. W1P 9AD.	Tel: 01-580 0670	311, Edgware Road, W2 1BN.	Tel 01-262 0387
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CY31	0·31	ECL82	0·31	PABC80	0·33
DAF96	0·40	ECL83	0·63	PC97	0·41
DF96	0·40	ECL86	0·36	PC900	0·42
DK96	0·43	EF36	0·40	PCC84	0·36
DL92	0·28	EF37A	1·13	PCC89	0·45
DL94	0·40	EF40	0·76	PCC189	0·49
DL96	0·40	EF41	0·76	PCE800	0·75
DM70	0·27	EF80	0·22	PCF80	0·25
DY86	0·29	EF83	0·49	PCF82	0·27
DY87	0·28	EF85	0·31	PCF84	0·54
DY802	0·43	EF86	0·27	PCF86	0·50
E88CC/01	1·08	EF89	0·25	PCF200	0·80
E180CC	0·37	EF91	0·27	PCF201	0·60
E180CC	0·90	EF92	0·31	PCF801	0·40
E182CC	1·08	EF95	0·31	PCF802	0·45
EA50	0·18	EF183	0·26	PCF805	0·80
EABC80	0·27	EF184	0·31	PCF806	0·60
EAF42	0·46	EFL200	0·67	PCF808	0·85
EB91	0·16	EL34	0·45	PCH200	0·60
EBC33	0·45	EL41	0·47	PCL81	0·40
EBC41	0·45	EL84	0·21	PCL82	0·30
ECC81	0·31	EL85	0·37	PCL83	0·50
EBF80	0·36	EL86	0·36	PCL84	0·35
EBF83	0·36	EL90	0·31	PCL85	0·35
EBF89	0·27	EL95	0·31	PCL86	0·43
ECC81	0·27	EL500	0·76	PFL200	0·51
ECC82	0·25	EM31	0·22	PL36	0·45
ECC83	0·27	EM80	0·36	PL81	0·40
ECC84	0·27	EM84	0·31	PL82	0·35
ECC85	0·36	EM87	0·63	PL83	0·36
ECC86	0·40	EY51	0·36	PL84	0·30
ECC88	0·33	EY86	0·40	PL500	0·62
ECC189	0·47	EY81	0·40	PL504	0·62
ECF80	0·31	EY88	0·40	PL508	0·70
ECF82	0·31	EZ41	0·45	PL509	0·90
ECF83	0·67	EZ80	0·22	PL802	0·74
ECF801	0·56	EZ81	0·24	PX4	2·50
ECF802	0·56	GZ34	0·52	PY33	0·50
ECH35	0·81	GZ37	0·63	PY80	0·35
ECH81	0·25	KT66	1·86	PY81	0·30
ECH83	0·36	KT88	2·18	PY82	0·23
ECH84	0·40	N78	1·60	PY83	0·35
ECH200	0·56	OA2	0·30	PY88	0·32
				PY800	0·35
				PY801	0·45
				QQVO 3-10	1·10

	£		£		£		£		£		£
R17	0·45	UBF80	0·35	VR150/30	0·30	5B254M	2·00	6AQ5	0·30	6C4	0·25
R19	0·35	UBF89	0·30	2800U	1·40	5B/255M	1·80	6AQ5W	0·45	6C6	0·20
STV 280/40	3·20	UCC85	0·35	Z801U	1·10	5R4GY	0·65	6AS6	0·30	6CH6	0·47
STV 280/80	8·20	UCF80	0·48	Z803U	1·10	5U4G	0·30	6AS7G	0·70	6CL6	0·42
TT21	3·30	UCH42	0·60	Z900T	0·90	5V4G	0·37	6AT6	0·25	6D6	0·15
U25	0·68	UCH81	0·25	1L4	0·25	5Y4G	0·35	6AU6	0·20	6EA8	0·50
U26	0·68	UCL82	0·30	1R5	0·30	5Y3GT	0·30	6AX4GT	0·50	6F23	0·60
U27	0·45	UCL83	0·50	1S4	0·30	5Z3	0·48	6AX5GT	0·60	6F33	1·35
U191	0·60	UV41	0·50	1S5	0·20	5Z4	0·75	6B7	0·35	6H6M	0·18
U801	0·70	UF80	0·30	1T4	0·18	5Z4GT	0·32	6BK7	0·60	6J4WA	0·65
UABC80	0·30	UF89	0·30	1X2A	0·36	6AB7	0·25	6BA6	0·20	6J5	0·35
UAF42	0·50	UL41	0·40	1X2B	0·45	6AC7	0·25	6BE6	0·20	6J5GT	0·20
UBC41	0·41	UL84	0·30	2K25	7·50	6AH6	0·45	6BG6G	0·47	6J6	0·18
		UU5	0·55	3A4	0·33	6AK5	0·25	6BJ6	0·35	6J7G	0·30
		UY41	0·32	3D6	0·15	6AK8	0·30	6BQ7A	0·35	6J7M	0·35
		UY85	0·30	3Q4	0·45	6AL5	0·13	6BR7	0·75	6K6GT	0·45
		VR105/30	0·30	3S4	0·33	6AL5W	0·35	6BW6	0·65	6K7	0·27
				3V4	0·42	6AM6	0·25	9BW7	0·80		
						6AN8	0·45				

	£		£		£
6K7G	0·17	30C15	0·65	6057	0·45
6K8GT	0·32	30C17	0·65	6060	0·50
6K25	0·60	30C18	0·60	6064	0·45
6L6M	1·35	30F5	0·68	6065	0·65
6SA7	0·35	30FL1	0·55	6080	1·50
6SA7GT	0·25	30FL12	0·95	6146	1·75
6SC7GT	0·20	30FL13	0·50	8020	2·00
6SG7	0·35	30FL14	0·65	9001	0·15
6SJ7	0·30	30L15	0·65	9002	0·20
6SJ7GT	0·28	30L17	0·65	9003	0·45
6SK7	0·40	30P12	0·65	9004	0·12
6SL7GT	0·27	30P19	0·65	9006	0·12
6SN7GT	0·27	30PL1	0·60		
6SQ7	0·30	30PL13	0·75	**C.R. Tubes**	
6SQ7GT	0·30	30PL14	0·73	VCR97	4·00
6V6G	0·15	35L6GT	0·42	VCR517R	5·00
6V6GT	0·30	35W4	0·30	VCR517C	7·00
6X4	0·25	36Z4GT	0·45	88D	8·10
6X5G	0·25	50C5	0·45	88J	8·10
6X5GT	0·30	50CD6G	0·45	88L	8·10
6Y6G	0·60	50EH5	0·50		
6-30L2	0·70	75	0·35	**Photo Tubes**	
6Z4	0·30	76	0·40	CMG25	2·50
7B7	0·45	78	0·40	931A	4·00
7Y4	0·60	80	0·45	6097C	16·00
9D6	0·30	723A/B	7·00		
11E2	2·70	803	3·00	**Special Valves**	
12AT6	0·25	805	12·00	CV2339	18·00
12AT7	0·25	807	0·50	JP9/7D	35·00
12AU7	0·24	813	4·00	K301	4·50
12AV6	0·25	832A	2·70	K305	11·00
12AX7	0·25	866A	0·80	K308	14·50
12BA6	0·25	931A	4·00	K337	14·50
12BE6	0·28	954	0·35	KRN2A	3·15
12BH7	0·23	955	0·20	WL417A	1·35
12C8	0·30	956	0·17	3J/92/E	35·00
12E1	2·50	957	0·25	5C22	18·00
12K5	0·48	991	0·35	714AY	3·60
12K7GT	0·35	2051	0·50	725A	16·00
12K8GT	0·40	5933	1·00		
12Q7GT	0·30				
12SG7	0·35				
1487	0·70				
19AQ5	0·40				
19G3	4·00				
19G6	1·35				
19H4	4·65				
20P4	1·00				
25L6GT	0·35				

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THE VALVE WITH A GUARANTEE

SPECIAL OFFER O9J TUBE £2·50 p & p 50p

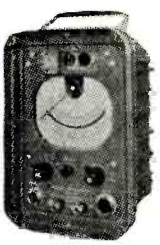
TRANSISTORS, ZENER DIODES

	£		£		£		£		£		£
OA5	0·20	OC71	0·12	1N702-725	0·36	3N139	1·75	ASY67	0·48	CRS3/40	0·50
OA10	0·25	OC72	0·20	1N823A	1·80	3N140	0·97	BAW19	0·28	CS2A	0·65
OA70	0·10	OC73	0·30	1N4785	0·50	3N154	0·95	BC107	0·10	CV102	0·25
OA71	0·10	OC75	0·25	1ZMT5	0·35	3N159	1·45	BC108	0·10	GET103	0·23
OA73	0·07	OC76	0·25	1ZMT10	0·33	6FR5	0·45	BC113	0·10	GET115	0·45
OA74	0·07	OC81	0·20	1ZT5	0·67	12FR60	0·73	BC118	0·20	GET116	0·50
OA79		OC81D	0·20	1ZT10	0·63	40954	1·25	BCY72	0·15	GEX66	1·50
(6D15)	0·10	OC81DM	0·20	2G385	0·51	40595	1·25	BF115	0·25	NKT222	0·20
OA81	0·08	OC82	0·25	2G403	0·51	40636	1·25	BF173	0·20	NKT304	0·50
OA91	0·07	OC82DM	0·30	2N918	0·37	40668	1·25	BFY51	0·20	RAS310AF	0·33
OA200	0·07	OC83	0·25	2N1304	0·22	40669	1·40	BFY52	0·20	SD91S	0·26
OA202	0·10	OC83B	0·15	2N1306	0·25	AC126	0·25	BS	0·45	SD92S	0·31
OA210	0·25	OC84	0·25	2N1307	0·25	AC127	0·25	BS2	0·47	SD93S	0·32
OA211	0·30	OC122	0·50	2N2147	0·64	AC128	0·20	BSY29	0·25	SD94	0·21
OAZ200	0·55	OC139	0·25	2N2411	1·50	AC176	0·20	BU100	1·80	SD98S	0·46
OAZ201	0·50	OC140	0·40	2N2904A	0·25	ACY17	0·25	BYZ13	0·25	V405A	0·40
OC16	0·50	OC170	0·25	2N2989	4·00	ACY28	0·17	BYZ16	0·63	Z2A51CF	0·78
OC22	0·50	OC171	0·30	2N3053	0·20	AD149	0·50	CRS1/10	0·25	ZR11	0·33
OC25	0·40	OC172	0·37	2N3054	0·50	AD161	0·35	CRS1/20	0·38	ZR21	0·46
OC26	0·25	OC200	0·40	2N3055	0·64	AD162	0·35	CRS1/30	0·40	ZR22	0·42
OC28	0·60	OC201	0·75	2N3730	0·50	AF118	0·50	CRS1/35	0·43		
OC29	0·60	OC206	0·95	2N3731	2·75	AF127	0·20	CRS1/40	0·48	**ZENER DIODES**	
OC35	0·50	1N21B	0·30	2N4172	0·50	AF139	0·30	CRS3/05	0·30	All preferred voltage	
OC36	0·56	1N25	0·60	82303	0·50	AF178	0·48	CRS3/20	0·38	½W	0·17
OC38	0·42	1N43	0·10	3F100	0·62	AF186	0·40	CRS3/30	0·43	1W	0·37
OC44	0·17	1N70	0·07	3FR5	0·32	ASY26	0·25	CRS25/025	0·55	1·5W	0·25
OC45	0·12	1N677	0·12	3N128	0·87	ASY28	0·25			7W	0·40
OC70	0·12										

MANY OTHERS IN STOCK including integrated circuits, C.R.T. and special valves. U.K. POSTAGE over £3 free, 5p for one valve plus 1p for each additional valve or transistor. C.O.D. 25p extra.

VALVES AND TRANSISTORS
Telephone enquiries for valves, transistors, etc., retail 743 4946; trade and export 743 0899.

MARCONI TEST EQUIPMENT



VALVE VOLTMETER TYPE TF 958. Measures AC 100mV; 150V DC 50mV to 100V, multiplier extends ac range to 1·5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. **£27·50.**

TF 1066 B/2 F.M. SIGNAL GENERATOR. Frequency range 400-555MHz in one band. Crystal calibration: 1MHz and 10MHz. Output: piston attenuator 0·1µV-100mV at 50 ohms. Int. mod. freq. 1 to 10kHz, ext. mod. freq. 100Hz to 100kHz. Freq. dev. up to 300kHz. **£225.** Carriage £1·50.

TF 1258A VHF SPECTRUM ANALYSER for analysis and measurement of Radar Equipment. Frequency range 190 to 230MHz with crystal check points. Sweep width 0·5 to 5MHz, output pulse delay (*a*) 85-175 µSec, (*b*) 0·7-1·4 mSec with ×1 and ×2 multiplier and ÷2, ×1, ×2 multiplier. Output 2µV to 20mV with ×10 multiplier. **£200.** Carriage at cost.

MUIRHEAD PHASEMETER. Type D729/AM and P.S.U. D729 A/S. Complete with manual, leads, as new **£200.**

TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT. For testing radar, nucleonics, 'scopes, counters, filters etc. **SPEC. TF 1400S.** Rep. frequ. 10Hz to 100 kHz, pulse width 0·1 to 100µ sec., delay —1·5 to +3000µ sec., rise time < 30N sec. **SPEC. TM 6600/S.** As for TF1400S except pulse width 0·5 to 25µ sec, delay 0 to + 300µ sec. **£230.**

SIGNAL GENERATOR TYPE AN/USM-16 (MODEL BJ75A)
A precision HF/VHF signal generator embodying facilities seldom found or contained in one instrument, namely outputs of **CW/AM/PM and swept carrier,** in the frequency range **10 to 440 MHz.** Some of the features of the instrument are: **AUTOMATIC FREQUENCY STABILISATION** (locks output signal to selected frequency), **AUTOMATIC LEVEL CONTROL** (holds output constant ±1db) **INTERPOLATION OSCILLATION** (for precise tuning between crystal check points) **MARKERS** (for S.F.M.)
Brief specifications, Frequency 10 to 440MHz, RF output 0.1uV to 0.224V at 50 ohms. Modes of operation CW-HI, CW, CW (calibrated and stabilised), AM-400Hz and 1kHz and external, FM-400Hz and 1kHz and external 0.75 kHzdev., S.F.M. —x1, x10, x100, 0-75, 750 & 7500kHz dev. resp., P.M. —50 to 5000 pps at 1 to 30µsec. width Int. or ext., 150 to 5000Hz rep rate. 3 meters for; mod. and dev., frequency discrimination pulse level output. With manual. Complete specification and price on application.

★ **Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.** ★

TF 801B/3/S SIGNAL GENERATOR. Spec. as for TF 801D/1/S except for minor circuit changes e.g. 1 and 2 MHz switched calibrator. P.O.A.

TF 801D/1/S SIGNAL GENERATOR. Range 10-485 MHz in five ranges. R.F. output 0·1 µV-IV source e.m.f. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator. 50Ω output impedance. Internal modulation at 1 kHz at up to 90% depth, also external sine and pulse modulation. Built-in 5MHz crystal calibrator. Separate R.F. and mod. meters. P.O.A.

TF 562B/3 Oscillator and Detector Unit.
TF 1226B, **TF 1225A**, **TM 577A** } White Noise Test Set.

TF 1104 VHF ALIGNMENT OSCILLOSCOPE combining sweep generator, markers etc. Frequency range 5kHz to 10MHz, 10MHz to 40MHz and 41 to 216MHz. Sweep width 500kHz to 10MHz, output 100$V to 10mV. Markers 0·5, 1 & 5MHz. Price £120.

HEWLETT—PACKARD
185A 800 MHz SAMPLING OSCILLOSCOPE WITH 188A DUAL TRACE PLUG-IN. Full spec. and P.O.A.

5248 COUNTER FREQUENCY MEASUREMENT: 10Hz to 10,1MHz. Accuracy ½ 1 count. Automatic positioning of decimal point. Period measurement: 0-10kHz, reads in seconds, milliseconds or microseconds, decimal point automatically positioned. Display on 6 neon lamp decades and 2 meters. Complete with manual and following plug-ins: **525A** 10 to 100MHz, **525B** 100 to 220MHz, **526A** video amplifier. Price on application.

540B TRANSFER OSCILLATOR. Extends range of 524 and 5245 series counters to 18 gHz, or on its own, measures frequencies below 4gHz with 0.5% accuracy.

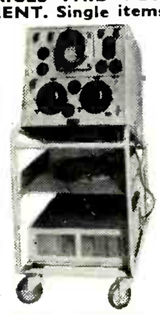
430C MICROWAVE POWER METER. Complete with **476A** bolo mount, **475B** tunable bolo, **BM16** waveguide, **£95.**

205AG AUDIO OSCILLATOR. Low distortion, 20 Hz to 200 kHz, metered and attenuated inputs and outputs enabling a very wide range of measurements to be made on amplifiers, filters, etc. **£125.**

200CD WIDE RANGE OSCILLATOR. 5 Hz to 600 kHz, £60.

BEST PRICES PAID FOR TEST AND COMMUNICATION EQUIPMENT. Single items or quantities. Private or Industrial.

SPECTRUM ANALYSER TYPEOA1094 Freq. range: 3 to 30MHz in 9 bands. Selectivity: 6 30 and 150Hz, at 3db. Spectrum width: 0-30kHz. Sweep Duration: 0.1, 0,3, 1, 3, 10 & 30 secs. Complete as illustrated, with manuals, etc. and **L.F. Adaptor.** Price upon application.



TF 1370 R-C OSCILLATOR, SQUARE AND SINE WAVE. Freq.: Sinewave 10Hz-10MHz, squarewave 10Hz-100kHz. Direct output: sinewave: 0-31.6V rms., 10Hz-1MHz, squarewave: 0-73.2pp 10Hz-100kHz. Attenuator range: —50d8 to +10dB. Impedance: 75, 100, 600Ω. Price upon application.

BC 624 RECEIVER (Part of SCR 522 TX/RX) 100-156 mcs, no valves, requires separate PSU for 28V. £2.50. Carriage 50p.

H.F. ABSORPTION WATTMETER TF 957. Range: 1 to 100MHz, Power: 0, 1 to 25w, Impedence 52Ω on 1W range, 70Ω on 25W ange. £22.50. Carriage 75p.

TEKTRONIX OSCILLOSCOPES.
541A—33MHz, plug-in Y amps.
531-57—60MHz, separate P.S.U.
561A—10MHz, solid state, compact, takes the following plugs-ins: X, Y, differential, sampling, spectrum analyser.
PLUG-IN UNITS
CA—24 MHz dual trace 50MV-20V.
G—20 MHz differential 50MV-20V.
L—30 MHz fast rise time 5MV-20V.
D—High gain differential 1MV-50V.
N 600MHz sampling 10mV-cm.
R Transistor measurement.
P type callibration.
3A1—Dual trace 10mV-10V.
3B3—Delayed sweep time base.
134—P6021 probe and current probe amplifier, 1mA-15A p. & p., new and boxed, **£125.**
EQUIPMENT
162 wave form generator.
163 Pulse generator.

500/250W MEDIUM WAVE BROADCAST TRANSMITTERS. Price and details on application.

M.O. for ET 4336 TX (see description in previous issues) **£8·50.** P. & P. £1·50.

AR88 SPARES. We hold the largest stock in U.K. Write for list.

5 PHASE AUTO TRANSFORMER, wye input 400v, wye output 241.5/230/218.5v 50c 18kVA. Made by Westinghouse of USA. Brand new in original cases £60.00 including UK transport.

PLEASE NOTE

Unless offered as "as seen"

ALL EQUIPMENT

ordered from us is completely overhauled mechanically and electrically in our own laboratories

FOR EXPORT ONLY
TRANSMITTERS:
BC 610 Hallicrafters.
RCA ET 4336 also modified version of increased output to 700w.
COLLINS TYPE 231D 4/5kw., 10 channel, autotone and manual tuning. All above complete installation and spare parts.
TRANSCEIVERS
19, 19HP, 38, 62.
C-11 TRANSMITTERS
C-13 TRANSMITTERS

V.A.T.
EQUIPMENT
PLEASE ADD
10%
TO ALL ORDERS

REMSCOPE TYPE 741 STORAGE OSCILLOSCOPE. On trolley, complete with plug-in trace shifter and two plug-in Y amplifiers. **£180** plus carriage.

HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.

R.F. METER 0-8 amp. 2½" (U.S.A.) **£1·80** P. & P. 15p.

METERS Full List of our very large stock of meters on request.

INTEGRATED CIRCUITS Texas SN 76131N Stereo pre-amp **£0·65.**

TR 1143 TRANSMITTER RECEIVER 100/126 mcs, requires separate PSU for 28V. Price **£12.00.** Carriage £1.50.

TELEPHONE TYPE "J" (Tropicalised) 10 line **MAGNETO TELEPHONE SWITCHBOARD**

100 line **AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD**

50 line **AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD**

Price of each of the above on application.

RADAR SCANNER ASSEMBLY TYPE C368 Parabolic assembly 17". Complete with motor for 26V 600W, etc. **£22·50.** Carriage £2·50.

★ **TELEPHONE ENQUIRIES** relating to **TEST EQUIPMENT** should be made to 01-748 8006 Extension 23. To view **TEST EQUIPMENT** please phone for appointment

COLOMOR (ELECTRONICS LTD.)
170 Goldhawk Rd., London, W.12
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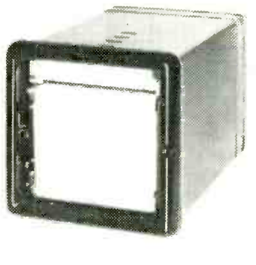
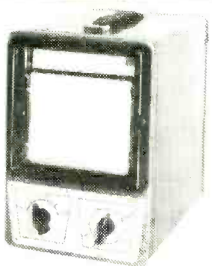
Electronic Brokers Ltd.~The



10 CHANNEL EVENT RECORDER

Designed for recording sequences of up to ten different operations, e.g. sequence of machine tool operation, switching sequences, etc. Record is presented in the form of square "pulses". When energised, pen moves by approximately 4mm. to the right of zero line. Response time 100 milliseconds. Chart width 110mm. Chart length 50ft. Inv. capacity 72 hours. Chart speeds 20-60-180-600-1800-5400 mm/hour. Size 160x160x255mm. Weight 9 lbs. Price complete with accessories

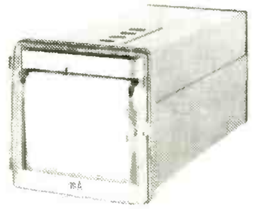
£52.00



PORTABLE AC/DC PEN RECORDING VOLTAMMETER

Fitted with separate zero-marking pen. Accuracy 1.5% DC, 2.5% AC. Measurements ranges — AC and DC: 5-15-150-250-500mA 1.5-5 Amps 5-15-50-150-250-500V. DC only 150mV. Frequency range 45 to 1000 c/s. Chart width 100mm. Chart speeds 20-60-180-600-1800-5400 mm/hour. Weight 22 lbs. Price complete with accessories

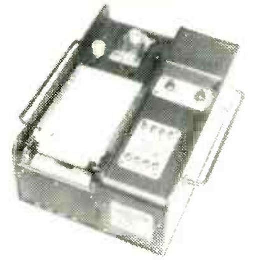
£78.00



MINIATURE PEN RECORDER

Provides permanent record of DC currents up to 1mA. Eminently suitable for use where space is limited. Separate time marker pen provided. Chart width 80mm. Chart length 40ft. Chart speeds: Slow 20-60-180 mm/hour. Fast 600-1800-5400 mm/hour. Dimensions 120x120x285mm. Weight 7.7 lbs. (3.5 Kg). Price complete with accessories

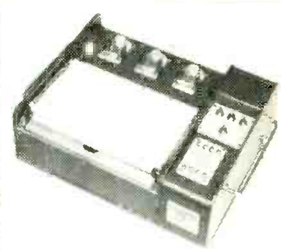
£39.00



SINGLE CHANNEL HIGH SPEED RECORDER

Chart length 175ft. Footage indicator. Width of recording channel 80mm. Chart speeds (selected by push buttons) 1.2-6-12-30-60-120-300-600-3000 mm per minute. Full deflection current 8mA. Internal impedance 210 ohms. External impedance 800 ohms. Dimensions 320x340x175mm. Weight 35 lbs. Price complete with accessories

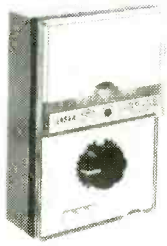
£55.00



THREE CHANNEL HIGH SPEED RECORDER

Strip Chart Recorder. Chart length 175ft. Footage indicator. Width of recording channel 80mm. Chart speeds (selected by pushbuttons) 1.2-12-30-60-120-300-600-3000 mm. per minute. Full deflection current 8mA. Internal impedance 210 ohms. External impedance 800 ohms. Dimensions 510x345x175 mm. Weight 44 lbs. Price complete with accessories

£90.00



AC/DC MULTIMETER

With taut band suspension movement. Sensitivity 20.000 ohms per volt on DC and 4.000 ohms per volt on AC.
Technical Data:
0.06-0.6-6-60-600mA-3 Amps DC
0.3-3-30-300mA-3 Amps AC 0.6-1.2-3-12-30-60-120-600 DC. 1200 Volts. 3-6-15-60-150-1300-600-900 Volts AC. 45 to 20.000 Hz.
500Ω. 5-50-500kΩ resistance. Decibel range −10 to +12dB. Accuracy (% of F.S.D.):—DC and resistance measurements ±2.5. Price with test leads, and storage case

£8.00

AC CLAMP VOLTAMMETER

Clamp-on Voltammeter is used for measurements of AC voltages and currents without breaking circuits.

Specification

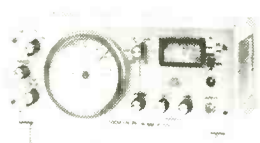
Measurement ranges:—Current 10-25-100-250-500 Amps. Voltage 300, 600 V. Accuracy 4%. Scale length 60mm. Overall dimensions 283x94x36mm. Weight 1.5 lbs.

Price £10.50

TV SWEEP MARKER GENERATOR Type VU 167

Suitable for alignment of tuned circuits in television sets. Incorporates a sweep generator, a market generator and a crystal-controlled oscillator operating at 5.5 MHz. Sweep frequency range 1-30 MHz. 170-260 MHz Fund. 470-780 MHz Harmonic. Marker frequency range 2-266 MHz. 480-800 MHz.

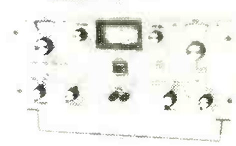
£195.00



AM-FM GENERATOR Type AF 1065

Permits fast and accurate calibration of modern radio receivers. Suitable for calibration and testing in the laboratory. AM frequency range: from 140 KHz to 46 MHz in 6 ranges expanded range 430-530 KHz. FM frequency range: 9.5-12 MHz; 85-110 MHz. Frequency accuracy: better than 1%. RF output voltage: adjustable from 0.1 μV to 0.1V. Output impedance 75 Ohm constant. Modulation: AM; FM; AM + FM. Amplitude modulation: 400 Hz from 0-50% adjust. Frequency modulation: 1000 Hz adjust. Deviation from 0 − +/ 50 KHz. External modulation: AM; FM: from 30 Hz to 15 KHz.

Price £225.00



RCL BRIDGE Type P 966

For measurement of RCL and capacitor dissipation factor and inductors figure of merit Q. Consists of a system of switchable bridges, a 1 KHz generator, and a sensitive tuned detector. Particularly suitable for testing of small production batches and selection of component parameters.
Measurement ranges:
Resistance: from 0.1 Ohm to 11 MOhm. Capacitance: from 1 pF to 1100 μF. Inductance: from 10 μH to 1100 H. Accuracy: +/− 1%. Dissipation factor D: from 1.10^{-3} to 50. Quality factor Q: from 0.02 to 1000. Internal oscillator: 1 KHz.

Price £170.00

Supertester 680R. Buy it for what it is. Or buy it for what it can be.

The Supertester 680R is a completely new concept in measuring instruments. In itself a high quality test meter with eighty ranges on a 128mm mirror backed scale, it is also the basis of a complete measurement system. With the addition of the appropriate accessories it can measure a wide range of values including light, temperature, gauss and phase sequence. And there are other accessories to greatly extend the 680R's range. The 680R System offers many advantages over conventional test meters including tremendous versatility and economy.

ACCESSORIES TO CONVERT THE SUPERTESTER 680R TO THE FOLLOWING:

Temperature Probe
Converting the range +30 to +200°C **£11.95**

Gauss Meter
For measuring magnetic field strengths **£11.95**

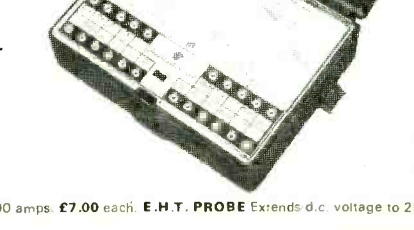
Phase Sequence Indicator
To indicate the phase sequence of a 3 phase supply **£5.95**

Signal Injector
Producing 1KHz and 500 KHz signals for circuit testing **£5.95**

Electronic Voltmeter
Input resistance of 11Mohms for d.c. and 1.6Mohms shunted by 10pF for a.c. **£18.00**

Amperclamp
For measuring a.c. currents from 250mA to 500 amps **£11.95**

Transistor Tester
For transistors and diodes **£11.00**



SUPER TESTER 680R
SPECIFICATION

13 D.C. ranges from 0.1 to 2000V. 12 ranges from 50μA to 5A 20.000 Ω/A Accuracy 1%. 11 A.C. ranges from 2 to 2500V. 10 ranges from 250μA to 4.000Ω/V. Accuracy 2%.
Resistance: 6 ranges from 0.5Ω to 100mΩ. **Reactance:** 1 range of 0-10M. **Frequency:** 2 ranges of 0.50 and 0-500CHz. **Output Volts:** 9 ranges from 10 to 2000V. **Decibels:** 10 ranges from −24 to −70dB. **Capacitance:** 6 ranges. 4 ranges from 20 to 20.000 mfd from internal battery and 2 ranges from 50.000 to 500.000pF using mains. **£18.50** complete with case and probes.

OTHER ACCESSORIES AVAILABLE. SHUNTS D.C. 25, 50 and 100 amps **£4.50** each. **CURRENT TRANSFORMERS** A.C. 25 and 100 amps **£7.00** each. **E.H.T. PROBE** Extends d.c. voltage to 25.000v **£5.95**

Test Equipment Specialists

3" SINGLE BEAM PULSE OSCILLOSCOPE

For display of pulsed and periodic waveforms in electronic circuits. Vertical amplifier: Bandwidth 10 MHz. Sensitivity at 100 KHz V RMS/mm 1.25. Horizontal Amplifier: Bandwidth 500 KHz. Sensitivity at 100 KHz V RMS mm 3.25. Preset triggered sweep 1 3000μ sec. Free running 20-200,000 Hz in nine ranges. Calibrator pips. Dimensions 220x360x430 mm. Weight 40 lbs. 115-230V AC operation.

Price £39.00

DOUBLE BEAM OSCILLOSCOPE

Designed for investigation and measurement of pulsed and periodic waveforms. The use of two independent vertical deflection amplifiers permits the display and analysis of two different waveforms simultaneously. Display area 35x90 mm. Repetition rates of investigated waveforms 50 Hz to 1 MHz. Range of pulse length 0.35μs to 1 sec. Range of amplitudes 0.04 to 400V. Maximum amplitude without external attenuator 100V. Characteristics of vertical amplifiers: Amplifier passband at 1db DC to 1 mHz. Amplifier passband at 3db DC to 5 mHz. Sensitivity at medium frequencies at broad passband 500mm/V. Size of undistorted pulse display 40mm. Input Impedance 0.5 + .015 Megohms shunted by 45pF. Input Impedance with external attenuator 5 Megohms shunted by 13pF. Voltage attenuation ratios of the built-in attenuator 1:1. 1:10. 1:100. 1:1000. Time Base: Preset calibrated sweep durations:—microseconds per cm 0.2: 0.5: 1: 2: 5: 10: 20: 50: 100. Milliseconds per cm 0.2: 0.5: 1: 2: 5: 10: 20: 50: 100. Free-running time base frequency range 50 Hz to 1 mHz. Sweep sync. voltage and trigger voltage 0.5V. Maximum trigger pulse repetition rate 10 kHz. Built-in amplitude calibrator. Amplitude of test pulses with duration of 0.35μsec or longer 0.04-100V. Fundamental error of the calibrator ± 10%. Frequency of quartz crystal calibrator 100 kHz. Overshoot of pulse top for pulses with rise time not below 0.1μsec 10%. Instrument warm-up time 30 min. Power inputs 220/250 ± 50 Hz. Overall dimensions 260x550x376 mm. Weight 55 lbs.

Price £87.00

WHEATSTONE BRIDGE AND CABLE FAULT LOCATOR

Measurement of resistance in the range of 0.005 to 1 megohm. Location of cable faults using Varley loop method. Location of cable faults using Murray loop method. Measurement of asymmetry of wires. Use of four-decade section as a resistance box. The bridge consists of four decade switches giving a range from 1 to 9999 ohms in 1-ohm steps. Accuracy: from 1 to 99,990 ohms 0.5%. from 0.1 to —.9999 ohms 1.5%. from 100k to 1 megohm 5.0%. from 0.005 to 0.0999 ohms 5.0%. Dimensions: 300x230x150 mm. Weight: Approx. 12 lbs. Price complete with connecting leads

£41.00

PORTABLE WHEATSTONE BRIDGE

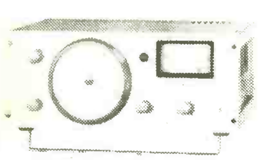
Designed for measurements of DC resistances in the range of 10^{-5} to 10^{6} Megohms. Basic accuracy 0.01 ohms to 10^{5} ohms is 0.2%. Dimensions 300x230x150 mm. Weight approx. 13 lbs.

Price £49.00

MULTIMETER

0.1-1-10-100-1000mA 2.5-10-20-250-500-1000V AC/DC. Sensitivity AC and DC all ranges except 10V-10,000 Ohm/V. Dimensions 212x118x75 mm. Weight 2.9 lbs. Price complete with steel carrying case and test leads

£4.95



LF SIGNAL GENERATOR Type G 1165 B

Transistorised generator providing wide range of squarewave and sinewave signals. Suitable for measuring distortion, gain or attenuation when testing the frequency response of low-frequency equipment.

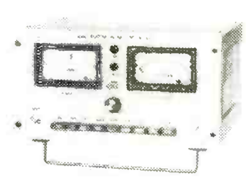
Sinusoidal output:—
Frequency range (in 4 ranges): from 10 Hz to 100 KHz. Output voltage: from 1 mV to 10 V. Output impedance: 600 Ohm constant. Frequency accuracy: better than 2%. Harmonic distortion: less than 0.3% (50 Hz 30 KHz).
Squarewave output:—
Frequency range (in 4 ranges): from 10 Hz to 100 KHz. Output voltage: from 100 mV to 10 Vp. Output impedance: 75 Ohm constant. Risetime: less than 10nS.

Price £165.00

DISTORTION METER Type D 566 B

Fully transistorised for measurement of overall distortion of signals with frequencies between 10 Hz and 1 MHz. Built-in electronic voltmeter can also be used separately for measuring AC voltage, basic noise, gain or attenuation over a wide frequency range.
Distortion meter:—
Frequency range (in 5 ranges): from 10 Hz to 1 MHz. Distortion factor (in 7 ranges): from 0.03% to 100. Minimum testing voltage: 300 mV approx. Input impedance: 100 KOhm : 40 pF approx.
Millivoltmeter:
Voltage range (in 12 ranges): from 1 mV to 300 V f.s.d. Level range (rel. to 0.776 V): from + 52 dB to − 75 dB. Frequency range: from 10 Hz to 2 MHz. Bandwidth (within 3 dB): up to 8 MHz. Accuracy: better than 5%. Input impedance: 2 MOhm : 50 pF approx.

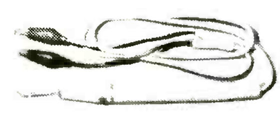
Price £249.00



WOW AND FLUTTER METER Type WF 971

Solid state, high stability unit. Can be preset for either the European standard at 3150 Hz or the American standard at 3000 Hz. Provided with built-in oscillator.
Specifications: DIN and CCIR. Input Signal: 20 mV rms to 20 V rms approx. Frequencies (switchable): 3150 Hz and 3000 Hz. Ranges (flutter): +/− 0.1% − 0.3° − 1° f.s.d. Drift indication: +/− 2% max. Input impedance: 10mOhm max. Built-in oscillator: 3000 Hz or 3150 Hz switchable. Stability: better than 0.1%. Shifts for calibration: +/− 0.1% dynamic. 50 Hz ± 2% static.

Price £225.00



MODEL 300 LOGIC PROBE

A compact easy-to-operate logic probe. As a light-emitting diode is used the unit actuates with low power. It does not affect the circuit under test because of high input impedance. Up to as high a frequency as 12 MHz.

Price £5.50

plus 75p. packing and carriage.

4-RANGE GENERAL PURPOSE TEMPERATURE RECORDER Type 01

Specially designed compact self-contained instrument for recording temperatures up to 500°C. The main design objectives were for an easy-to-use, robust instrument suitable for use in the laboratory and in the field. The four ranges are 10°C, 50°C, 100°C and 500°C. These are selected by push buttons allowing full use of the 3" wide chart. Two chart speeds 1" and 6" per hour are provided by the 240V 50Hz synchronous chart drive.

The 3% basic accuracy of the instrument, which is adequate for most applications, has been achieved without introducing stability problems in the d.c. amplifier, making the recorder ideal for use in schools, colleges and universities and by unskilled personnel. The recorder is complete with N1Ch/NiA1 thermocouple and mains lead. This product is brand new and manufactured in our own laboratories with three month guarantee.

Price £95.00

plus £5.00 packing and carriage.

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WW—103 FOR FURTHER DETAILS

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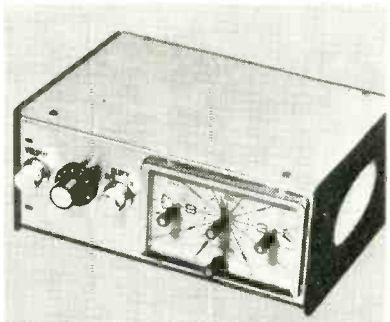
with 8 step-by-step constructional articles on these simple projects!

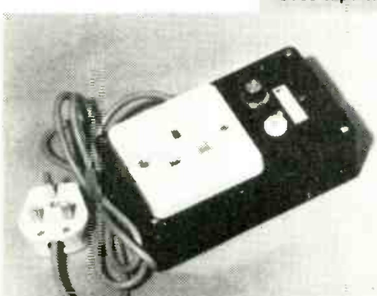
Easy to follow instructions from the top designer of these items for the modern home makes each project simple and satisfying to construct. Take your pick. This fully illustrated supplement is printed on eye-catching green paper for easy identification.



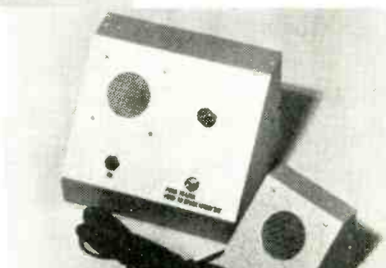
RADIO ALARM CLOCK
Uses tape tuner with an amplifier.

And another reason for getting this rewarding and extra large issue is to find out about next month's competition with 4 special prizes of **digital multimeters** each worth almost **£50**.

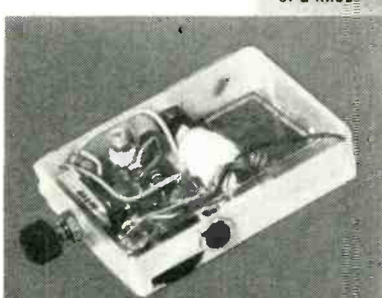
Show your metal and make some of these!



LAMP DIMMER
Reduces the lighting level at the turn of a knob

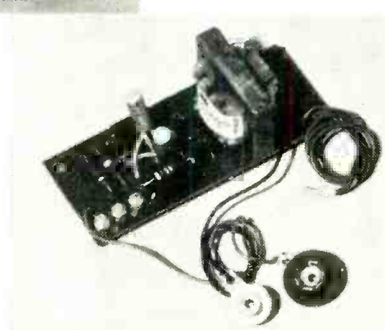


INTERCOM AMPLIFIER
2-way communication for kitchen, garage, workshop or sickroom.



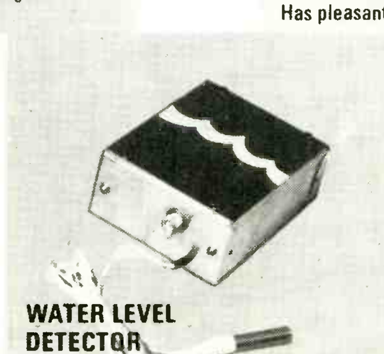
LIGHT POWERED RADIO
Operated by daylight, or strong artificial light.

BABY ALARM
Transmits sound of baby crying or door or telephone bells.



TWO-TONE DOORBELL
Has pleasant-toned peal effect.

TAPE TUNER
Portable medium wave tuner to feed a tape recorder or amplifier.



WATER LEVEL DETECTOR
Warns when water in bath or tank reaches a predetermined level.

Many more constructional articles plus our regular features all in the **May** issue on sale April 6.

price **20p**

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01-994 6275

COMMUNICATIONS EQUIPMENT

POCKET V.H.F. F.M. RADIOTELEPHONE
Cossor Type CC2/8 Mk. 2.
Fully transitorised transmitter/receiver available in two versions:—
Low band; Freq. range 71.5-104MHz. R.F. Output 500mW.
High band; Freq. range 140-174MHz. R.F. Output 300mW.
Size: 15.2 x 12.1 x 3.5 cm.
Complete with ¼ wave whip aerial, combined microphone/loudspeaker and 13.3V. rechargeable nickel-cadmium DEAC battery **Price £75** + v.a.t.
U.H.F. 2 watt FIXED RADIO LINK. 24V. dc./240V. ac. F.M. TRANSMITTER/Type CC RTX 4A Mk. I
R.F. Output 2W at 450-470MHz.
RECEIVER/Type CC RR4A Mk. I
Price £80.00 per unit
Full Technical and operating data available. Prices and details on request. Mains Power Pack for the above **£12.00 each.**

I + I CARRIER EQUIPMENTS. Cossor Type CC M2A.
Solid state multiplex installations designed for U.H.F. radio systems enabling 2 speech channels each with out of band signalling, if required or the equivalent in telemetry information, to be transmitted simultaneously over a radio system.
Prices and details on request.

V.H.F. RADIOTELEPHONE BASE STATION. Cossor Type CC 603 Transmitter. Simplex or duplex operation, local or remote control with talk through facilities, using double sideband a.m. modulation.
Low-band 71.5-104MHz. or High-band 156-174MHz. versions available.
RF. Output power 25W. into 50 Ohms.
24V. dc. operation. **Prices and details on request**
OPTIONAL POWER SUPPLY Type CC 101 for type CC603 base station P.O.A.

D.C. POWER PACKS

Price each

ADVANCE
PM 31 4–30V I Amp Stabilized £12
PM 46 30–50V I Amp Stabilized £20
DC 23 48V 4 Amp Constant Voltage £14
DC 23 12V 4 Amp Constant Voltage £10
DC 4 12V 4 Amp Constant Voltage £10

COUTANT
ED 200/12/12 5–30V 2 Amp Dual Stabilized £45
ES 500/26 6–30V 5 Amp Stabilized £35

ENGLISH ELECTRIC CO.
EE T 2053 12V 20 Amp Stabilized £40
EE Z–O–B Mk. 2 Triple Stabilised Supply .... p.o.a.
EE K78008 .... p.o.a.

FARNELL
IR 24/10 24V 10 Amp Stabilised £40
STE 234 30V I Amp + 10V 2 Amp Dual Stabilised £38

ROBAND
P 1695A 10–12V 10 Amp Stabilised £25

All above units are NEW and UNUSED.
Carriage extra £1 per unit.
ALL PRICES EXCLUSIVE OF V.A.T.
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Price each

ADVANCE. Constant Voltage Transformers.
Type CV25/108. Input 102–138V. Output 6V. rms. 25W £4
Type CV50F. Input 190–260V. Output 12V. rms. 50W £5
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TRANSMOTOR. Rotary Convertor.
Type FO–15. Pri. 11V. Sec. 115V./sec. 60Hz. 0;25kVA/HP £15
APELCO. A.C. Voltage Regulator.
Type 7227A. Input 100–140V. 50–70Hz. Output 115V. ± 3½ £20
SANDERS. Laboratory Magnetic Amplifier.
Type L 026. Three circuits in one unit, viz.; separately excited, series excitation, auto self excited. Max. output 20W £55

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Type LC 100–C Range 0·1μH.–100mH ... £50
PYE ETHER. Transducer Indicator Type PML 6009 .... £24
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ADVANCE. Volstat Mains Adjustable Stabilizer £10
Temperature Controller Type TCN2 .. £8
COSSOR. Fast Resitime Square Wave Generator Type 1090 .... £8
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Type L 356558. Measures Volts 50, 100, 250, 500V. fsd. Amps 0·5, 1, 2·5, 5, 10, 25 A fsd. Watts 0–250W. fsd. .. £55
Decade Bridge Type L 358113 .... £60
CROYDON PRECISION INSTRUMENTS. Kelvin Bridge Ohmeter Type KB 1 .... £60
ADVANCE. D.C. Power Supply Type DC1 21. Input 115–250V. ac. Output 18–0–18V. dc. £8

COSSOR. V.H.F. A.M. Receiver Series R109 .. £50
V.H.F. A.M. Transmitter Series R109 .... £50
V.H.F. A.M. Radiotelephone Type CC301 (incomplete) £25

RANK DATA SYSTEMS. E.H.T. SUPPLY. 24KV. 6mA. Stabilized Oil filled cooling. Therefore buyer must collect .... from £10

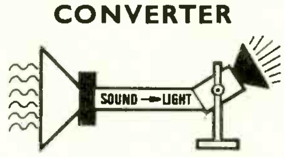
CONTROL DATA CORPORATION.
Magnetic Tape Transport 9120
7 Track 75 ips. Recording density 800, 556 or 200 frames/in. Compatible with CDC 603, 604, 606, 607, 163, 164, 1607, and IBM 729 I-VI, 727, 7330 units.
Character rate; 800, 556, or 200 bpi. density.
Full set of operating and maintenance manuals available. Only 1200 hrs. use.
Fully operational and ready for use £350
Tape Transport Exerciser 699.
Used to check out the above tape transport without tying up the computer system. Complete with manual £75

MOVING IRON AMMETERS
2½ in. SQUARE

Available in the following values:—
0–1–4 Amp
0–1·5–6 Amp
0–1·5–9 Amp
0–5–15 Amp
0–5–30 Amp
0–8–48 Amp
0–15–45 Amp
0–30–180 Amp
0–40–240 Amp
0–50–200 Amp
0–50–300 Amp

All Brand New and Boxed ONLY £1·75 inc. p.p.

SINGLE CHANNEL
SOUND-TO-LIGHT CONVERTER



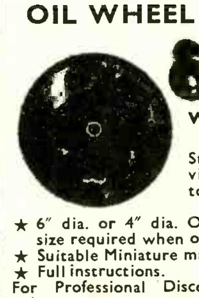
WITH LIGHT DIMMER
Max. load 2kW. at 250v. A.C.

When connected to the output of an audio amplifier the unit modulates the brightness of any filament light bulb proportionally with the loudness of the sound source.
Price includes ready built and tested module, edge connector/mounting bracket, dimmer potentiometer, audio sensitivity potentiometer, full connecting data.
Price £6·95 + 25p p.p.
EXTRA FACILITIES. Push-button for Manual Pulsing 25p extra. Photocell for turning on the lights as the ambient light decreases, 75p extra.

3 CHANNEL FILTER UNIT

When used with three single channel modules this unit filters the sound into bass, middle and top frequencies enabling three coloured light displays to be shown. Independent sensitivity controls on each channel. Ready built and tested.
Price £2·95 + 15p p.p.

OIL WHEEL PROJECTOR



Build your own using our
MULTI-COLOURED OIL WHEEL AND MOTOR KIT

Suitable for mounting on virtually all Slide Projectors.
Kit contains:
★ 6" dia. or 4" dia. OIL WHEEL (please state size required when ordering).
★ Suitable Miniature mains motor.
★ Full instructions.
For Professional Discotheque use or home enjoyment. **Price £6·50** inc. p.p.

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GEX 541 D2P1 .... £3·00
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S6AN20 20A 600V .... £5·00
S8BR8 8A 800V .... £2·50
S15BR8 8A 1500V .... £5·00
S3BN8 8A 300V .... £1·75

POWER DIODES

S2BN25 25A 200V .... £1·75
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S2AN70 70A 200V .... £3·25
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OA211 4A 800V .... £0·40

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Thousands of panels containing INTEGRATED CIRCUITS, POWER TRANSISTORS, small modern transistors, diodes, hi-stab resistors, etc., etc.
PRICES FROM 20p–£1·50.
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Full range in stock from 1μF–10,000μF.
SPECIAL OFFER. (Limited period only.)

MULLARD ELECTROLYTIC CAPACITORS
Axial Lead Types 437/426

2·5V		4V	
40μF	4p	64μF	4p
160μF	4p	125μF	4p
320μF	4p	250μF	4p
550μF	4p	400μF	4p
1000μF	5p	800μF	5p
1600μF	7p	1250μF	7p
2500μF	8p	2000μF	8p
4000μF	9p	3200μF	9p

6·4V		16V	
25μF	4p	250μF	8p
100μF	4p	640μF	8p
320μF	4p	**40V**	
640μF	5p	250μF	8p
1600μF	8p	400μF	9p
2500μF	9p	**64V**	
		160μF	8p

SOLDER TAG TYPE 431

320μF	64V	17p	2000μF	16V	19p
500μF	40V	17p	3200μF	10V	19p
500μF	64V	19p	3200μF	16V	25p
800μF	25V	17p	4000μF	25V	35p
800μF	64V	24p	5000μF	10V	25p
1250μF	16V	17p	6400μF	16V	37p
1250μF	25V	19p	6400μF	25V	45p
1250μF	40V	24p	10000μF	10V	38p
1600μF	64V	35p	10000μF	16V	46p
2000μF	10V	17p	16000μF	10V	46p

OSCILLOSCOPES

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Revscope S.O.1 Storage Scopes .... from £100
COSSOR
CDU.110. Double beam DC—20MHz. Brand new with manual £300
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ELECTRONIC COMPONENTS

BARGAIN COMPONENT PACKS

Pack No.	
1	500 Carbon resistors, ¼, ½, 1, 2 watt.
2	100 Electrolytic Condensers.
3	250 Ceramic, Polystyrene, Silver Mica., etc., Condensers.
4	250 Polyester, Polycarbonate, Paper, etc., Condensers.
5	25 Potentiometers, assorted.
6	250 High-stab, 1%, 2%, 5% resistors.
7	50 Assorted Tagstrips.
8	1lb Assorted nuts, bolts, washers, spacers, etc.
9	25 Assorted switches, rotary, lever, micro, toggle, etc.
10	50 Preset Potentiometers.

ALL COMPONENTS NEW AND UNUSED.
£1 + 25p p.p. per pack. **£5** for 5 packs p/free.

	Price	p.p.
MERCURY WETTED RELAYS		
Elliott Brothers Ltd.		
Type 61987/48 2p C/O Coil 4K + 4Kohm		
Type 61999/1 2p C/O Coil 5K + 5Kohm	**£1**	10p
LEVER KEY SWITCHES		
(to P.O. type 1000)		
4p make—OFF—4p make 3 psn.		
2 c/o lock—off—2 c/o mom posn.	**50p**	10p
TEN TURN HELICAL POT		
Bourns type 3500S—1—203		
20Kohm ± 3% ± 0·2%	**£1**	10p
NUMERICATOR TUBE		
S.T.C. Type GN 4	**£1**	10p
SUB-MINIATURE MICROSWITH		
S.P.C.O. 5A. 250V. Silver contact		
Lever actuated. Size 20 × 9 × 6·5 mm	**25p**	10p
10 for	**£2**	10p
ADJUSTABLE POT CORE		
Type LA 1	**75p**	10p
DRY REED RELAY. B. & R. Type RO4.	**60p** each,	10p.
Change over moulded reed relay. Coil Res. 500Ω 8-12V. operation.		

	Price	p.p.
MECHANICAL FILTERS		
Kokusai Type MF 455—30W		
455kHz ± 3kHz b.w.	**£5** inc. p.p.	
CRYSTAL FILTER		
10·7 MHc Cathodeon type BP25		
S.T.C. type 455/LQU/901B	**£5** in. p.p.	
QUARTZ CRYSTAL		
5MHZ Marconi type QM263B Glass envelope	**£1**	10p
HC6U 470kHz. Crystal		
HC6U 454.875 kHz Crystal	**£1**	10p
CERAMIC RESONATOR		
Toko type CFT470C	**35p**	5p

LOUDSPEAKERS

Low cost suitable for Transistor Radios, Car Radios, Budget Stereo systems etc

DIAMETER	IMPEDANCE (ohms)	POWER (Pk.) (watts)	PRICE	P.P.
56 mm.	8	0·25	**80p**	12p
70 mm.	8, 80	0·25	**80p**	12p
3 in.	3, 25	0·5	**95p**	15p
5 in.	3, 8	3	**£1·22**	18p
6½ in.	3	4	**£1·75**	21p
8 in.	3, 15	5	**£2·15**	25p
8 in.	8	5	**£2·45**	25p
6×4 in.	3, 8	3	**£1·30**	21p
7×4 in.	3, 8, 35	3	**£1·40**	21p
8×5 in.	3, 8	5	**£1·50**	25p
10×6 in.	3, 8, 15	7	**£2·60**	30p
HIGH QUALITY SPEAKERS AND ACCESSORIES				
4 in. High compliance 40-16000 Hz.	8	10 (5 rms)	**£3·95**	25p
5 in. Midrange unit 800-8000 Hz.	8	30 (15 rms)	**£3.98**	25p
6½ in. with Integral tweeter 35-18000 Hz.	8	20 (10 rms)	**£5·95**	37p
8 in. with Integral tweeter 30-18000 Hz.	8	25 (15 rms)	**£7·95**	37p

3-WAY SPEAKER KIT Main Drive Unit 210 mm. dia. with Parasitic 70 mm. concentric mid range unit.
10 Watts rms. Freq. 30-12000 Hz.
20 Watts peak. Tweeter 68 mm. dia. 2000-16000 Hz.
8 ohm. Crossover; Mounted L/C Network. Freq. 3000 Hz.
Price **£11·95**+45p p.p. Complete with full cabinet plans.

TWEETERS. All types require Crossover freq. of 3000 Hz.

Type	Impedance (ohms)	Power (rms)	Freq. Range	Mounting Hole	Price	P.P.
CT 5	8	5	3-15 kHz	94 mm.	**£1·10**	15p
CT10	8, 16	10	1·5-16 kHz	80 mm	**£1·85**	15p
HT 15	16	15	2-18 kHz	54 mm	**£3·15**	20p
HT 21	8	20	2·5-20 kHz	63×43 mm	**£3·75**	20p
MHT 10	8	20	2-18 kHz	54 mm	**£3·20**	20p
DT 33	8	30	2-18 kHz	72 mm	**£4·60**	20p

CROSSOVER NETWORKS
2 Way L/C Networks available in either 3, 8 or 16 ohm version.
Crossover freq. 3000 Hz — Price **£1·00**+15p p.p
3 Way L/C Network 8 ohm version only
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½W ,, ,, 10-10M E24 ,,	**1p**	**0·9p**	**p·8p**
1W ,, ,, 10-10M E12 ,,	**2·5p**	**2·3p**	**2·1p**
2W ,, ,, 10-10M E12 ,,	**6p**	**5p**	**4·5p**
½W 2% Metal Oxide 10-1M E24 series	**4p**	**3·5p**	**3p**

Wirewound Resistors 5% 2·5/3 Watt **7p** ea.
5/6 Watt **9p** ea.
10 Watt **10p** ea.

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Horizontal and Vertical 100 ohms-5 Mohm.
Sub-miniature **7p** each; Miniature **12p** each.
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Rectilinear, Multiturn 10 ohms-25 Kohms **60p** each.

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Linear Law: 1K, 2K5, 5K-2 Mohm. Single **19p** each. Double gang **46p** each.
Log Law: 5K, 10K, 25K-2 Mohm. Single **19p** each. Double gang **46p** each.
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Mfd.	
·001	400V. 600V. 750V.
·0015	400V.
·0022	400V.
·0033	50V. 200V.
·0047	250V. 400V.
·005	100V.
·01	100V. 250V. 400V.
·015	125V.
·02	100V. 250V. 350V.
·022	160V. 250V.
·025	350V.
·03	350V.
·033	250V.
·04	250V.
·047	125V. 160V. 250V.
·05	350V.
·068	160V. 250V. 400V.
up to 250V.	**3p** each
over 250V.	**5p** each

Mfd.		
·1	100V. 250V. 350V.	**5p**
·1	400V.	**7p**
·15	250V.	**5p**
·22	200V. 250V.	**5p**
·25	350V.	**6p**
·33	100V. 160V. 250V.	**7p**
·33	400V.	**9p**
·47	160V.	**8p**
·47	400V.	**12p**
·5	350V.	**10p**
·68	100V. 125V. 250V.	**11p**
1	160V.	**14p**
1	250V.	**15p**
1	400V.	**18p**
1·5	250V.	**21p**
2·2	250V.	**24p**
4·7	160V.	**42p**

VEROBOARD

SIZE	MATRIX ·1in.	MATRIX ·15in.	PLAIN ·15in.
2½×1in.	**7p**	**7p**	—
2½×3¾in.	**25p**	**18p**	**15p**
2½×5in.	**29p**	**27p**	**17p**
3¾×3¾in.	**29p**	**27p**	—
3¾×5in.	**32p**	**32p**	**25p**
2½×17in.	**83p**	**62p**	**52p**
3¾×17in.	**92p**	**85p**	**67p**
5×17in.	—	—	**90p**
3¾×17·9×·1in.	—	—	**85p**

PINS: Single sided **35p** per 100; Double sided **38p** per 100.
VERO-cutter **45p**; Insertion tools **55p**.
VERO EDGE CONNECTORS: 0·15in. 16 way **28p**; 24 way **36p**.
0·1in. 24 way **36p**; 36 way **42p**.

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S.T.C. Brand New 2 pole c/o 6800 ohm coil—**15p** ea.

CARPENTERS polarised Single pole c/o 20 and 65 ohm coil as new, complete with base **37p** ea.

Single pole c/o 14 ohm coil **33p** ea.; Single pole c/o 45 ohm coil **33p** ea.

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with thorough knowledge of recording techniques and several years of experience in the audio field.

Please write to:—
**Loulou Gasté Studios
5 Rue Due Bois De Bologne,
PARIS 16**

EDITORIAL VACANCY

Electronics/radio engineer or physicist with ability to write good English is required by WIRELESS WORLD as Technical Journalist. Experience in circuit design an advantage. Preferred age about 25.
Applications in writing please to:

**THE EDITOR, WIRELESS WORLD,
DORSET HSE., STAMFORD ST., LONDON, SE1 9LU**
[2572

Electronics Technician

£1,602-£2,076

A new post maintaining electronic engineering equipment in York Hospitals, with excellent career prospects.
The successful candidate will possess O.N.C. and preferably H.N.C. (Electronics).
For job description and application form write to:— Group Secretary (Personnel), Bootham Park Hospital, York, Y03 7BY. Closing date: April 25.
YORK 'A' HOSPITAL MANAGEMENT COMMITTEE [2582

RADIO OFFICERS would you come ashore for £2,300 a year?

As a Radio Operator with the Post Office Maritime Service you can continue your career ashore in an interesting and expanding service. And earn over £2,000 a year, including compulsory pension contributions, at 25 years of age working only a 41-hour week of shift duties —with overtime this could rise to £2,300 and possibly more.

Post Office Radio Operators benefit from a shorter pay scale than sea-going officers. You have good opportunities for promotion to positions earning basic salaries of up to £3,290, and prospects of further advancement into Post Office Senior Management.

To apply you need to be 21 or over and to hold a 1st class or General Certificate issued by the MPT or an equivalent certificate issued by a Commonwealth administration or the Irish Republic.

If you would like to know more, please write to the Inspector of Wireless Telegraphy, Post Office, IMTR/WTS1.1.3, Union House, St. Martin's-le-Grand, London EC1A 1AR. L47

Post Office Telecommunications

91

TEST GEAR ENGINEER

Telefusion Vision Limited is a brand new company in the Colour Television manufacturing industry and we now find that due to expansion we need an engineer to take charge of our testing equipment in conjunction with our Development Laboratory.

The successful applicant will have some experience in the television or a similar industry and be prepared to accept the responsibility for the development and maintenance of the equipment used in the production testing of colour television receivers.

Qualifications will probably be City and Guilds Radio & Television Servicing, with Colour Certificate, or O.N.C. Electronics.

Please write stating qualifications, age, experience and present salary to:

Miss V. M. Hammond,
Personnel Manager,
Telefusion Vision Limited,
Cobden Mill,
Gower Street,
Farnworth,
Lancashire.
2556

BRITISH RELAY TV

As a result of massive nation-wide contracts with H.M. Government and Local Authorities, we have a steadily expanding work programme

OVER THE NEXT 21 YEARS

We need to recruit

CATV ENGINEERS

THROUGHOUT THE COUNTRY

We offer:-

- **Good rates of pay**
- **Permanent position with excellent prospects**
- **Private use of company vehicle**

Applicants should have:-

Up-to-date knowledge, initiative and ability in the field of **COMMUNAL AERIAL or TELEVISION RELAY WORK** whether in planning installation, commissioning or maintenance

All enquiries will be treated in strict confidence.

Write to:-

The General Manager, Special Services Division,

BRITISH RELAY TV

41, Streatham High Road, London, S.W.16
or Telephone 01-677 9681

2571

Design Engineers

Grow with Britain's fastest expanding name in Medical Engineering

GEC Medical Equipment Limited is Britain's leading manufacturers of medical and industrial X-ray equipment. Our products carry names that have been famous since X-rays were a new discovery — names that are trusted for quality and reliability throughout the world.

We have now embarked on an unprecedented expansion programme which is increasing our representation of UK markets and making important new inroads overseas. Consequently we now need more design engineers — with electrical or mechanical backgrounds — to play a major part in developing the products that will ensure our continued expension in the future.

They will work on one of more of the following key areas of our operation:

ELECTRICAL DESIGN

Small and medium power transformer design
Electronics circuitry
Digital circuits with read-out displays
Automatic test equipment

MECHANICAL DESIGN

Mechanisms with finely controlled movements
Electro-mechanical design
Patient handling equipment

Applicants should be qualified in electrical or mechanical engineering at least to ONC standard — ideally to HNC or degree standard — and must have several years practical experience.

All the posts carry attractive salaries which are negotiable according to experience. Other benefits include pension and sickness schemes, and up to 4 weeks holiday in a full year.

Please write or telephone for an application form to:
P.B. Blackmore, GEC Medical Equipment Limited, East Lane, North Wembley, Middlesex.
Tel: 01-904 1288.
Evening or weekend interviews will be arranged if required.

G.E.C. Medical

2455

UNIVERSITY OF WALES

THE WELSH NATIONAL SCHOOL OF MEDICINE

ULTRASONICS IN CLINICAL DIAGNOSIS

Applications are invited from physicists or electronic engineers who would be interested in an opportunity to develop a swept focusing system for ultrasonic pulse-echo diagnosis. This project will be financed by a grant from the Medical Research Council, and the appointment would be for a period of two years in the first instance. The salary would be equivalent to that of a senior physicist in the NHS (first year: £2,613; second year: £2,733), but previous experience in ultrasonics is not necessary, and the appointment could be made at a less senior level.

Further particulars of this appointment may be obtained from Professor P. N. T. Wells, Department of Medical Physics, University Hospital of Wales, Cardiff, CF4 4XW (telephone 0222-755944 extn. 2005). Applications, giving the names of two referees, should be sent to the Registrar, Welsh National School of Medicine, Heath Park, Cardiff, CF4 4XN.

[2551

SENIOR ELECTRONICS TECHNICIAN

in Department of Biological Sciences

required immediately

To be responsible for the construction, maintenance and operation of electronic and other instruments, especially those used in Neurophysiology. The successful candidate must possess the relevant qualifications at HND/HNC or CGLI level.

Salary £1,518-£1,878, plus £174 London Weighting Allowance.

Apply in writing, giving full details of qualifications, experience, etc. and including the names and addresses of two referees, to the Head of Department of Biological Sciences, City of London Polytechnic, Sir John Cass School of Science and Technology, 31 Jewry Street, London, EC3N 2EY.

[2532

HM PRISON AND BORSTAL SERVICE

VOCATIONAL TRAINING INSTRUCTORS

(Civilian Instructional Officer, Grade III)

All applicants should have served a full apprenticeship or have had equivalent recognised training followed by at least five years industrial experience in the Radio and Television and/or Electronics servicing industry. City and Guilds Certificate (or equivalent) is desirable. Teaching or instructing experience are added advantages.

RADIO AND TELEVISION SERVICING posts at
HM PRISON, LEWES, Sussex.
HM PRISON, The Verne, PORTLAND, Dorset.

DUTIES: The successful candidates will train inmates in Radio and Television servicing and prepare them for City and Guilds examinations.

SALARY: The commencing salary at age 28 or over is £1956 (slightly less if younger) rising to a maximum of £2371. The posts are pensionable with prospects of establishment, i.e. permanent appointment.

HOURS: A 40-hour, 5-day week is worked with 4 weeks and 2 days annual leave in addition to the usual 9 public and privilege holidays.

WRITE FOR APPLICATION FORM TO: The Establishment Officer, Home Office, Personnel and Administration Department, Portland House, R.10/10 (2T), Stag Place, London, SW1E 5BX, stating for which post you apply.

Closing date for the receipt of completed application forms: 3 May, 1973.

[2577

ELECTRONIC SERVICE ENGINEERS

Swan's of Manchester are looking for two experienced Electronic Service Engineers, one for the Manchester area and the other for the Birmingham area.

These positions involve bench and outside work on electronic organs, quality hi-fi systems and colour television.

We are looking for men who are capable of working without supervision and who have a knowledge of circuitary from valves to L.S.I. technology. The successful applicants should hold clean driving licences as they will be provided with Company vehicles.

Excellent starting salaries will be offered to the successful candidates.

Apply in writing, giving full details of experience, to:

**W. Swan, Jnr., Esq.,
SWAN'S OF MANCHESTER LTD.,
84-86 Oldham Street,
Manchester,
M4 1LF.**

[2537

Telecommunications Technicians

for 1000-VDU network
up to £2665

The Home Office is currently nearing completion of the first phase of a project, planned to go into operation shortly, that will provide a fast, round-the-clock information service for police throughout the UK. Backed by a configuration, based on twinned Burroughs B6700 processors and situated at Hendon, that will be one of the most powerful real-time computer systems in Europe, the information service will require an extensive data communications network, with up to 1000 VDUs and Dataprinters located throughout the UK.

You will be responsible for ensuring the efficient and continuous operation of this vital network.

The level of appointment depends on age and experience but most of the successful candidates will be appointed at the higher level. Salary scales £2365-£2665 and £1605-£2365. Maximum starting salary £2365. You should be at least 23, and must hold ONC Engineering with a pass in Electrical Engineering "A", or a recognised etquivalent. In addition you should normally have at least 5 years' experience of skilled work on telegraph and data transmission equipment. Prospects of promotion to higher posts. Non-contributory pension scheme.

For full details and an application form (to be returned by 10 May, 1973) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone Bassingstoke 29222 ext. 500 or London 01-839 1992 (24-hour answering service). Please quote reference T/8238/1.

Home Office

[2581

RADIO ENGINEER

NEW HEBRIDES

£5175 + Gratuity

Required by the Condominium Radio Department to be responsible to the British and French Resident Commissioners for all radio telecommunications. A good oral and written knowledge of the French language is essential.
Candidates, preferably 35-45 years, must be MIEE or equivalent and have had considerable recent experience in the planning, installation and maintenance of modern high frequency radio-telecommunication systems including medium power transmitters, receivers, aerials and all ancillary equipment required for telephony and machine telegraphy operation.

- NO INCOME TAX in the New Hebrides at present
- Accommodation at low rental
- Appointment Grant £100-£200 normally payable
- Free family passages
- 25% Gratuity (excluding 15% Territorial Allowance)
- 3 year tour
- Education and outfit allowances
- Holiday visit passages

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Overseas Development Administration of the Foreign and Commonwealth Office.

Apply to:
CROWN AGENTS,
M. Division, 4, Millbank, London, SW1P 3JD for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/721013/WF.

[2527

ST. JOHN'S COLLEGE, YORK

Closed Circuit Television

CHIEF TECHNICIAN

Applicants are invited for the post of Chief Technician to take charge of an exceptionally well equipped Educational Television Unit at St. John's College of Education consisting of a studio complex, a mobile recording vehicle and related equipment. Two additional technical assistants are employed.

The successful candidate will be responsible for the general management of the technical area. In addition he will assist the Director of the Television Service with the making of programmes using a one inch helical Scan editing machine.

Suitable applicants should have experience in general technical and studio duties with an educational television unit and be able to offer the minimum qualification of City and Guilds Radio and Television Finals.

Salary will be on the Local Government A.P.T.C. Technicians and Technical Staffs Grade 6/7 (£2,100-£2,661) according to experience and qualifications.

Further particulars may be obtained from The Bursar, St. John's College, Lord Mayor's Walk, York, YO3 7EX.

[2575

TECHNICIAN
(GRADE 3)
£1539-£1794

in
AUDIO-VISUAL/AUDIO-LINGUAL LABORATORY

A full-time vacancy exists in this rapidly expanding Department. The successful candidate would take a prominent part in the day-to-day running of the Department's language laboratories. Technical experience with tape-recording apparatus and associated equipment, and experience of film, slide or film-strip projection are essential skills.
Applications forms may be obtained from the Staff Officer, University of Surrey, Guildford, Surrey. Tel.: Guildford 71281, Ext. 452, and to whom they should be returned to by: 7 May 1973.

[2526

Stockwell College of Education,
The Old Palace, Rochester Avenue,
Bromley BR1 3DH.

SENIOR AUDIO VISUAL AIDS TECHNICIAN

required by mass media department. Ability to operate and service all types of audio Visual Aids, including tape recorders, 8 mm and 16 mm film projectors, Language Laboratories, teaching machines, etc. A knowledge and operation of C. C. T. V. useful but not essential. Ability to give instructions to students groups in the use of Audio Visual equipment is imperative.
Applications forms and particulars available from the Senior Administrative Officer, at the above address.

[2528

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Educational Technology Unit (Television Services)

TECHNICAL POSTS

The Educational Technology Unit has vacancies for three Television Engineers who would work predominantly in the University's television studio. Successful applicants would be responsible to the Director of the Unit through the Manager, Television Engineering.

The Duties attached to the posts would include—maintenance and operation of the unit's television studio and distribution system, assistance in the building and installation of equipment in the projected new studio, and, in the case of one post, general service and maintenance on electronic and audio-visual teaching equipment within the University.

The Unit's present studio is equipped with 3 Plumbicon cameras, flying-spot telecine, 15 channel vision mixer, and one inch recording equipment. A Rediffusion "Dial-a-programme" distribution system is being installed on the campus. A further two-studio Educational Technology Unit Centre is under construction, to be equipped with colour facilities and designed to be operational in 1975/76.

The salary will be negotiable and will be determined on the basis of the age, qualifications and experience of the persons appointed.

Fringe benefits include pension and medical aid facilities, a housing subsidy, and an annual vacation savings bonus.

Applications, giving full personal particulars and details of qualifications and experience, should be lodged with the London Representative, Witwatersrand University Office, Chichester House, 278 High Holborn, London W.C.1., before **11 May 1973.**

[2566

Electronic Organ Service Engineer

required for expanding organ business in Sussex. Company Car. Good salary and prospects.

Apply in writing to

SOUTHERN ORGANS (Horsham) LTD.
HONEYWOOD HOUSE, ROWHOOK, HORSHAM, SUSSEX.

[2525

Gestetner

Gestetner Limited, the world's leading authority in the field of business office machinery and office equipment, have the following vacancies due to expansion in their Electro-Mechanical Development Laboratory at their Head Office based in Tottenham.

DEVELOPMENT ENGINEERS

Aged 25-35. H.N.C. or equivalent. Experienced in developments of electronic and electro-mechanical equipment.

TECHNICIANS

Aged 25-35. O.N.C. or equivalent. Experienced in the construction and maintenance of valve and solid state electronic equipment.

Please write with details of experience, qualifications and present salary to:

Mr L. J. Simmonds, Personnel Officer, GESTETNER LIMITED, P.O. Box 466, London N17 9LT.

Gestetner

ELECTRONICS TECHNICIAN

REQUIRED FOR FILM PROCESSING DIVISION

PERMANENT POSITION

Servicing electronic equipment and carrying out design work for Production departments.
Applicants should be O.N.C. level, should have experience of transistor and integrated circuits.
Salary £2.000 per annum.
Telephone for interview : 01-542 6262

The Personnel Officer,
AGFA-GEVAERT LIMITED,
Deer Park Road,
Wimbledon, SW19 3UG

[2553

DESIGN ENGINEER

20-30 year old General Electronic Design Engineer with some experience in Antenna design required for small expanding Company.

Must be capable of working by himself.

He should be willing to assist on test supervision and occasional visits to customers.

Please apply to:

Mr. D. A. R. Wallace — Managing Director,
Antenna Specialists UK Limited,
Thame Industrial Estate, Bandet Way,
Thame, Oxfordshire. Tel: Thame 3621/2

BENCH SERVICE ENGINEERS

Feltham — Ascot Road
Bedfont

We require Bench Service Engineers with previous experience of TV (Monochrome and Colour), Radio, Hi-fi and Tape Recorders for our Central Service Division. Preference will be given to holders of City & Guilds qualifications, though sound practical experience may outweigh formal qualifications.

Earnings will be in the range £1,600–£2,200 depending on qualifications and experience. In addition there are L.Vs, a Staff Purchase Scheme and a Contributory Pension Plan. Hours are 9 a.m. – 5.30 p.m. Monday to Friday.

We would be interested to hear from experienced Engineers, who wish to work with products that are renowned for quality and reliability.

Write with details of past experience and current salary to:

Personnel Manager,

SONY (UK) LIMITED, Pyrene House, Sunbury-on-Thames, Middlesex.

SONY®

2536

One of our clients, a rapidly growing and diversifying company, in the field of television and sound broadcasting, and recording, are interested in speaking to you if you have experience in the following areas.

Managing Installation and Planning Engineer

Wide experience in television and sound broadcasting and recording systems essential, including experience in technical liaison and interpretation of Customer requirements, preparation of block systems diagrams, etc.

£3,500-£4,500 plus Company car and usual fringe benefits. Based West London and Home Counties.

Senior R.F. Transmitter/Systems Engineer

Experienced in 1-80 KW u.H.F. trasmitters and television studio systems practice, preferably with working knowledge of installations and systems planning, Customer liaison, etc.

£2,500-£3,500 plus usual fringe benefits. Based West London and Home Counties.

Senior Station Engineers—Overseas Contracts

Experienced in television and sound broadcasting studio practice, able to train and lead local staff and take responsibility for smooth station on-air performance.

Up to £6,000 p.a. and expenses according to Contract.

Write, or ring, in complete confidence, for brief application form.

STUART J. TAIT,
Lansdowne Recruitment Limited,
Design House,
The Mall, London, W5 5LS
01-579 6585

[2589

SPANISH COMMUNICATIONS EQUIPMENT MANUFACTURER

Has an immediate opening for An experienced Design and Development Engineer for Audio Equipment, including Highly Professional Mixing Desks, Compressors, Limiters, Audio Monitoring Amplifiers, etc. Systems Experience is desirable.

Send resumé to:
NORTRON
Fernando el Católico, 63
Madrid 15
SPAIN

[2540

CHIEF TECHNICIAN

£1908—£2205

GIPSY HILL COLLEGE, KINGSTON

To head a team in the Educational Aids Department which serves the needs of the whole College.

Good knowledge of electronic equipment, including c.c.t.v. servicing, and relevant qualifications, will be expected.

There is considerable responsibility attached to this key appointment. Salary within scale according to qualifications.

Details from Senior Administrative Officer, Gipsy Hill College, Kenry House, Kingston Hill, Kingston upon Thames. Tel. 01-549 1141.

[2552

Ipswich and District Hospital Management Committee

X-RAY ENGINEER

(Salary range £1,911 to £2,508 p.a.)

ELECTRONICS TECHNICIAN

(Salary range £1,602 to £2,076 p.a.)

Candidates for both posts should possess H.N.C. or equivalent qualifications, but consideration will be given to suitably qualified and experienced candidates in these fields. Successful candidates will be members of a new and expanding department, servicing a wide range of electronic/bio-medical and diagnostic X-ray equipment.

Application forms and job description can be obtained by either telephoning Ipswich 56481, Ext. 33, or writing to the Group Engineer, Ipswich and District H.M.C., 26 Broughton Road, Ipswich, IP1 3QS. Reference GE/E/2.

[2529

THE OPEN UNIVERSITY

Faculty of Technology

Electronic Technician/ Engineer (Grade V)

A vacancy exists in the electronic laboratory for a Technician/Engineer. The electronics laboratory provides electronic support for:-

(a) design and development of special pieces of equipment for home experimental kits.

(b) assistance with demonstration equipment for television and summer schools.

(c) electronic support for research work.

Appointments will be made within the Technicians' scale Grade V—£1881-£2241 per annum according to qualifications and experience.

Application forms and further particulars are available from The Open University (TT3) P.O. Box 75, Walton Hall, Milton Keynes, MK7 6AL. Closing date: Wednesday, 25th April, 1973.

[2586

LEICESTERSHIRE

Loughborough Technical College

Principal: F. Lester, B.Sc., Ph.D., F.R.I.C.

Required September 1973

LECTURER, GRADE 1

to teach ELECTRONIC WORKSHOP PRACTICE, RADIO AND TELEVISION SERVICING TECHNIQUES AND ELECTRONIC PRINCIPLES in full and part-time courses to F.T.C. level. Applicants should be suitably qualified and have had recent trade experience.

Salary scale (under review) £1,500-£2,525 with additions for good honours graduates, commencing point according to qualifications and experience.

Further particulars may be obtained from the Principal, Technical College, Radmoor, Loughborough, LE11 3BT, to whom completed applications should be returned within 14 days of the appearance of this advertisement.

[2578

BOOKS

ESSENTIAL BOOKS

HOW TO MAKE WALKIE-TALKIES FOR LICENSED OPERATION. Practical Working circuit diagrams and constructional details with explanations on permitted use and operating hints. 40p. 10p P. & P.
THE GOVERNMENT SURPLUS WIRELESS EQUIPMENT HANDBOOK. Contains circuits, data, illustrations for British/USA receivers, transmitters, trans/receivers. With modifications to sets and test equipment. Latest impression £3·25 including postage.
PROBLEMS IN ELECTRONICS WITH SOLUTIONS. A must for the student, technician, engineer. 349 problems and how the answers are arrived at. Includes every type of problem likely to be found in electronics, including semi-conductors, amplifiers, aerials, filters, CRTs, computers, power supplies, etc. 307 pages. Only 90p, postage 10p.
COSMIC RADIO WAVES. Start a new hobby—Radio Astronomy. This big book of 444 pages is an ideal handbook for the beginner and established enthusiast. Numerous photographs, illustrations and circuits. Published by Oxford University Press. £2·50. 25p P. & P.
A DICTIONARY OF SCIENTIFIC UNITS. Important reference book for the student & technician. Lists and defines units which have been or still are being used in Common Market Countries and throughout the world. Includes all dimensionless numbers and scales used in science. 204 pages. Only 50p. 10p P. & P.
HANDBOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES. Includes many thousands of British, USA and Japanese transistors. 78 pages. Only 40p and 5p P. & P.
HANDBOOK OF RADIO, TV AND INDUSTRIAL TUBE AND VALVE EQUIVALENTS. 40p. 5p P. & P.

GERALD MYERS (WW)
Bookseller and Publisher
18, Shaftesbury Street, Leeds LS12 3BT.
Extra postage for abroad.

TECHNICAL BOOKS (D.I.Y.)

Pal Receiver Service (280 pp.)	£3·50
Introduction to Video Recording (128 pp.)	£1·50
Making and Repairing Transistor Radios	£1·00
Handbook of Basic Electronic Equipment	£1·75
Transistorized Radio Control for Models	£2·50
How to Repair Small Appliances (128 pp.)	£1·20
Transistor Radio Servicing Made Easy (144 pp.)	£1·70
Car Radio Servicing Made Easy (128 pp.)	£1·30
Hi-Fi Projects for the Hobbyist (128 pp.)	£1·00
Tape Recording for the Hobbyist (160 pp.)	£1·30
Radio Handbook (896 pp.)	£6·00
Electronic Experiments and Projects (128 pp.)	£1·25
1-2-3-4 Servicing Stereo Amplifiers (240 pp.)	£2·50
Transistor-TV Servicing Guide (128 pp.)	£2·25
Solid State Servicing (160 pp.)	£2·50
99 Ways to Improve Your S.W. Listening	£1·75
99 Ways to Improve Your Hi-Fi (Elect. Proj.) ea.	£1·50
101 Easy Ham Radio Projects	£1·50
101 Ways to Use Your Colour TV Equipment	£1·25
Electronic Games, Toys You Can Build	£1·40
Electronic Servicing For The Beginner	£1·70
Tape Recording Servicing Guide	£1·75
How To Build Speaker Enclosures	£1·50
99 Electronic Projects	£1·50

Add 10% for Postage and Packing

WHEEL (W)
41a Adelaide Grove, London, W12

[31

DIGITAL Computer Logic and Electronics. Four volume self instructional course £2.95 (incl. P&P). Money back guarantee. Cambridge Learning (WW), 8A Rose Cres., Cambridge. [2584

SHORT WAVE MAGAZINE, now in its 36th year and published monthly, covers the whole field of Radio Amateur transmission and reception including regular news features (DX, VHF, Clubs and SWL) and the design, construction and operation of AMATEUR Radio equipment of every type. Cover price 25p at newsagents. Specimen copy 30p post free, first class. Annual subscription £3.00 (or £2.75 second class posting) year of 12 issues.—Circulation Dept. (W) Short Wave Magazine Ltd., 55 Victoria Street, London SW1H 0HF. (Tel: 01-222 5341/2). [2385

SCOTTISH HOME AND HEALTH DEPARTMENT

WIRELESS TECHNICIAN

Applications are invited from men, aged 17 or over, for five posts of Wireless Technician in the Scottish Home and Health Department. The posts are located at Montrose, East Kilbride, Edinburgh, Cambusbarron (Stirlingshire) and at a location still to be decided. The candidate appointed to the Cambusbarron post will be required to serve at Darvel, Ayrshire for an initial period.

QUALIFICATIONS : (1) 4 posts—Sound theoretical and practical knowledge of Wireless engineering and wireless communications equipment, including VHF and UHF equipment. Possession of an HN or C & G certificate an advantage but provision may be made for those who wish to continue their studies for one of these qualifications. The work involves installation and maintenance of equipment located a considerable distance from headquarters. Candidates must be able to drive private and commercial vehicles and have a clean driving licence.

(2) 1 post—Wireless Technician with Radiac duties. Post based at Cambusbarron, Stirlingshire, applicants require a sound theoretical and practical knowledge of electronic engineering as applied to radiac instrument techniques. Oversight of testing, repair and calibration of radiac instruments comprising personal dosimeters, charging units, fixed survey meters, contamination meters, training simulators, and portable survey meters. Again some travelling will be involved and a candidate must be able to drive private and commercial vehicles and have a clean driving licence.

SALARY : £1155 (age 17) to £1715 (age 25 or over) : scale maximum £2025.

These are unestablished appointments with prospects of establishment after one year's continuous satisfactory service.

Application forms and further information may be obtained by writing to the Scottish Office Establishment Division, Room 172, St. Andrew's House, Edinburgh EH1 3BX quoting reference PM4/3/73. Closing date for receipt of completed application forms is 15 May 1973.

[2550

RADIO OFFICERS

DO YOU HAVE { PMG 1 / PMG 11 / MPT / 2 YEARS OPERATING EXPERIENCE } POSSESSION OF ONE OF THESE QUALIFIES YOU FOR CONSIDERATION FOR A RADIO OFFICER POST WITH THE COMPOSITE SIGNALS ORGANISATION

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on scale rising to £2,365 p.a.; commencing salary according to age — 25 years and over £1,664 p.a. During training salary also by age, 25 and over £1,238 p.a. with free accommodation.

The future holds good opportunities for established status, service overseas and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Application only from British-born UK residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

Full details from:

Recruitment Officer (TRO.2.)
Government Communications Headquarters
Room A/1105
Oakley Priors Road
CHELTENHAM Glos GL52 5AJ
Telephone: Cheltenham 21491 Ext 2270

ENGINEERS FOR FIELD COMMISSIONING

Molins Limited are a major British Group engaged in precision engineering and are the world leaders in the design and manufacture of the products in its field.

The Company has vacancies for experienced Electronics Engineers who must have a thorough knowledge of semi-conductors and whilst H.N.C. or equivalent qualifications are desirable candidates with suitable experience and sound theoretical knowledge of complex electronic control equipment will be considered.

Applicants should be capable of working independently in customers' factories anywhere within the world carrying out installation, commissioning, and servicing duties for a period of several months.

The successful candidate would currently be earning in excess of £2,000 p.a. and can expect a salary in the region of £2,400 p.a. increasing to circa £2,600 p.a.

Generous assistance given for any necessary relocation expenses.

Apply, providing full personal and career details, to:

The Personnel Manager, Molins Limited, Evelyn Street, London, S.E.8. 5DH.

or telephone (reverse charges) 01-237-4581 Ext. 201 2587.

1966 THE QUEEN'S AWARD TO INDUSTRY

MOLINS Limited

1970 THE QUEEN'S AWARD TO INDUSTRY

Due to Warehouse Clearance we have a few low powered F.M. VHF Wireless Station Type A. A.F.V. No. 88. Contained in two units. (1) Transmitter/Receiver. (2) 12 volt Power Unit and L.F. Amplifier.
The TX and RX are contained in a water proof diecast Alloy Case, using a total of 14 valves, operates on four switched channels which are Crystal controlled. All 4 Crystals are supplied, and are the same in each set.
Therefore all sets will transmit and receive to each other, provided each are switched to the same channel out of the four.
The stations are supplied with Mounting Carriers, 2 Vertical Whip Aerials, plus Aerial Base, Spare Valves, Bulbs, Mounting Screws, Connectors etc.
Including the Operating Manual giving all details, plus circuits of the Wireless set.
All above items are individually boxed and wrapped, placed in original Transit case.
ABSOLUTELY BRAND NEW. Made by Echo for the Government no expense spared, few only available at £9,50, carriage £2.

RADIO TELETYPE TERMINAL SET
A. Type, AN/SGGIA latest Government release of these sought after units, housed in metal case approx. size 8in. x 19in. x 16in. deep. Using a total of 11 valves, supply voltage 115 volts 50 c/s.
Containing Meter switched for checking. send and receive Bias, Send and Receive Level, Loop and Plate current, in fair used ex-Government condition. Few only available at £7·50, carr. £1.50.

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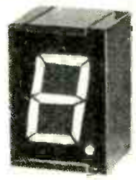

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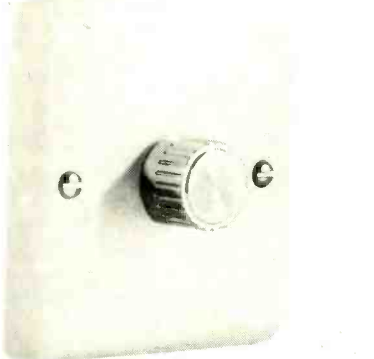

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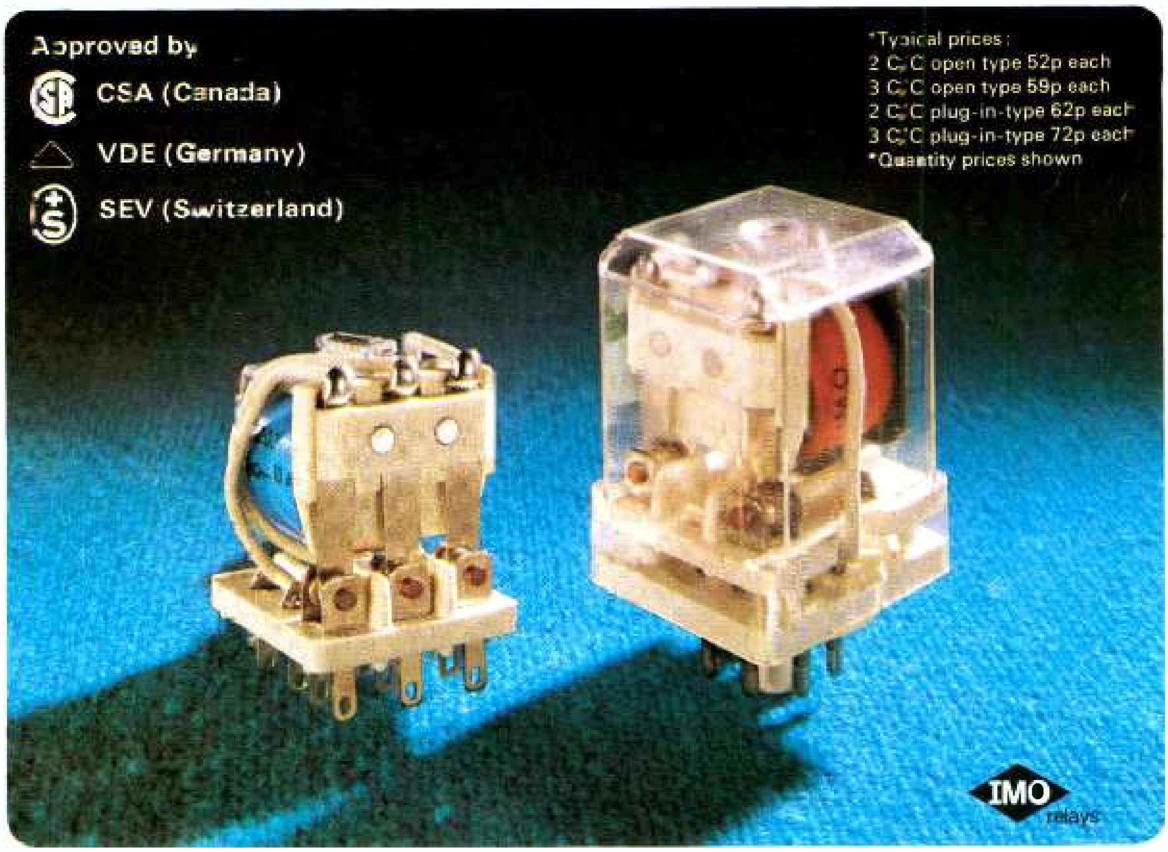

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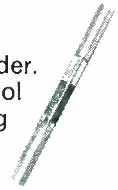

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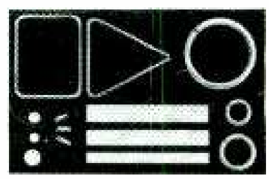

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